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CONTENTS

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GORDON GUNTER 1

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STUDIES ON MARINE FISHES OF TEXAS

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Commission

With Foreword
by

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Professor of Physiology and Director of the
Institute of Marine Science

Published by
The University of Texas
Austin

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Foreword

In conjunction with the establishment of the Institute of Marine Science, and development of its research activities, it was planned to provide for appropriate publication of results of investigations on various phases of oceanography of the Gulf of Mexico.

History of the development of research activity at most of the well established marine laboratories shows that faunistic and ecological studies of marine organisms were among the first to appear in print. One of the obvious immediately practical reasons for this is the desirability of having available a large amount of information about the occurrence and the distribution of organisms available in the regions adjacent to the laboratory.

The rich body of information presented by Dr. Gunter about the fish population in the coastal area of the Gulf is, therefore, a timely contribution, and should serve as a background of useful and interesting information for fishermen as well as future students and investigators of marine biology.

It is hoped that many other similar investigations on regions of the Gulf may be forthcoming.

E. J. Lund, Professor of Physiology and
Director of the Institute of Marine Science
The University of Texas.

Errata

p. 64.—to third sentence under *A. probatocephalus* add: in Copano Bay.

p. 66.—delete last line of first paragraph under *B. chrysura.*

p. 72, line 8.—read Gunter 1941c instead of 1941b.

p. 78, line 12 from bottom.—read table 48 instead of table 9.

p. 84, line 3 under *S. marmoratus.*—read table 51 instead of table 60.

p. 121.—add to bibliography: Gowanloch, J. N. 1933. Fishes and fishing in Louisiana. La. Dept. of Conservation Bull. No. 23, 638 pp.

p. 122.—add to bibliography: Jordan, D. S. 1905. A guide to the study of fishes. 2 vols. Henry Holt and Co. New York.

Acknowledgments

I am greatly indebted to Mr. J. B. Arnold, Director of the Coastal Division of the Game, Fish and Oyster Commission, who gave me a free hand in carrying on the work and made available the equipment and boats needed. In the same way I am indebted to the officials of the Game, Fish, and Oyster Commission as a whole.

Chief helpers in the field were Mr. Ben A. Earp and Mr. Lonnie Wright, who gave many hours of assistance both on the water and ashore. Mrs. Erlene Buckley gave extensive assistance in compiling the data. Mrs. Thelma Ratisseau helped with the typing and drew the figures. I am sincerely grateful to all of them because the project could not have been completed without their assistance.

Identification of the fishes was a sizeable task within itself. It was greatly facilitated by exchange of information with Mr. J. L. Baughman, of Houston, Texas. He was also kind enough to check the manuscript. Dr. Samuel F. Hildebrand and Dr. Carl L. Hubbs helped with some identifications and I am indebted to them. Thanks are due to Dr. Waldo L. Schmitt for help with the crustacea. Nevertheless, I must take responsibility for all errors, for practically all identifications were made in the field.

Finally I am indebted to Dr. E. J. Lund for many helpful conferences during the progress of the work and the preparation of the manuscript.

The Author.

I. Introduction

A vast number of fishes over the world spend part or all of their time in waters of continental coasts, which are neither fresh nor fully marine. The relations of distributions of practically all species to salinities of the water are known only in a general, unsatisfactory way. Knowledge of the movements and changes in distributions induced among fishes, and other animals as well, by normal salinity change of coastal waters is meager. These relationships will have to be worked out before the life history of any coastal fish can be understood completely. The life histories of at least the most important species must be known before effective steps in the conservation of marine fisheries can be taken. Knowledge of the relation of marine animals to the salinity factor is also of importance to other phases of biology, particularly physiology, zoogeography and evolution. A chief purpose of this study was to gather information on the distributions of Texas coastal fishes as related to salinity of the water. In the same way, but with less emphasis, the relations of fishes to temperature and temperature change were also studied.

Another chief aim of the work was to get a general view of the populations and distributions of the fishes in the shallow Gulf and bay waters and their changes during the seasons of the year. The work was also done in such a way that data on the life histories of several species were gathered, although specific life history work was not attempted. The relative abundance of the various species of fishes in the region is of importance to the general ecological picture and that topic is also treated. The effect of cold waves on the animals in the shallow bays of this region is large. Data on this subject were collected and are presented. Observations on the invertebrates were made and will be presented elsewhere. They were concerned chiefly with the common crustacea and were incidental to the work on fishes, but the data on the common shrimp and common crab are rather extensive.

The western Gulf of Mexico is the least known marine area of the continental United States. Some of the fishes are undescribed and the taxonomic status of many is uncertain. No check list of Texas marine fishes has ever been made. Evermann and Kendall (1894) listed 112 species from the Texas Coast. Their list is far from complete, but it is the most extensive to date. The compilation of a long check list of Texas marine fishes was not an aim of this work and no attempt was made to collect any given species. Nevertheless, all of the common species, except a few living on oyster reefs, and many of the rare species of the shallow coastal waters were taken. The reef fishes of offshore waters and several of the larger pelagic fishes are not represented. A complete list of Texas marine fishes would probably include 200 or more species. In this work 115 marine or brackish water and 4 fresh water species were taken.

In brief, an attempt was made to sample the whole population of fishes every month at given stations extending from the mouth of the Aransas River in Copano

Bay through Aransas Bay to five miles offshore in the Gulf of Mexico. This covers a typical physiographic sequence of the Texas Coast. It extends over an airline distance of 40 nautical miles and a salinity gradient from very near fresh water to pure sea water. Stations were visited from March, 1941, to November, 1942, with the most intensive work being done from June, 1941, to June, 1942. Temperatures and salinities were taken at each station. For location of stations see Figure 1.

II. Physiography of the Region

WHERE THE WORK WAS DONE

Texas has a double coastline consisting of an offshore bar and the mainland shore. The mainland is separated from the bar by the coastal lagoon. This holds true for the whole coast except where the Brazos delta has crossed the lagoon and now borders on the open Gulf of Mexico. The Colorado River delta seems to be rapidly approaching the same status (Price and Gunter, 1943). The coastal lagoon is from 3 to 6 miles wide. At such places as Corpus Christi Bay and Matagorda Bay the distances between the mainland shore and the bar are much greater than 6 miles in some places, but such expanses of water include embayed areas which are not parts of the lagoon proper.

The offshore bar is cut into a series of barrier islands by the tidal inlets leading into the coastal lagoon. The inlets form immediately south of larger bays from which most drainage comes. Natural inlets are entirely lacking on the 130 mile length of Padre Island, where the land drainage is very small.

The present river mouths emptying into the lagoon became embayed by wave and wind action. The hard northers of the winter, the strong prevailing southeasterly winds of the spring and summer, especially of the spring, and the hurricanes are active today in the continuing embayment process (Price, 1933, figs. 5, 9). The direct agent of this wind action is water—the waves and currents. Emptying into the coastal lagoon are a series of river mouth bays. Two of the bays, Alazan and Copano, are parallel; the others are transverse to the shoreline. Copano Bay was embayed at the mouths of both the Aransas and Mission Rivers. Aransas Bay is a part of the coastal lagoon.

The innermost bays of the Texas Coast act as deposition bowls for most of the sediments brought down by the rivers and probably they are shallowing up rapidly, as geological processes go. Price has presented data showing that, on the contrary, the outer bays have maintained constant depths during a long period. This does not hold true for the Laguna Madre (Price and Gunter, *op. cit.*), which is a special case. The innermost bays are shallower than most of the lagoonal portion of Texas inside marine waters, again excepting Laguna Madre.

The shape of Copano and Aransas Bays can be seen on the map. The average depth of Copano Bay is 7 feet at mean low tide, with a depth of 8 feet in some spots. The bottom is gray mud except on oyster reefs. Two oyster reefs cross the bay perpendicular to its long axis and another extends most of the way across, as shown on the map. Another reef extends across the mouth of the bay. These reefs lie at depths of from 6 feet to 1 foot and some are exposed at mean low tide. It seems to be the nature of oyster reefs to generally extend transversely across or perpendicular to the long axis of bays. This is at right angles to the direction of general current flow. The reason for this orientation of oyster reefs is unknown.

All drainage into Copano Bay comes from the Aransas and Mission Rivers, except for some short creeks. The waters of Copano Bay are always turbid to some extent and may vary from a muddy brown, after high winds, to a clearer greenish gray in color.

The gray sediments of the bays give the water a reddish color when viewed obliquely, due to a diffraction of light, and red streaks are often seen behind shrimp trawls, oyster dredges or passing towboats. However, there are no red muds in either bay and the muddy streaks are always gray when viewed perpendicularly from above.

The marginal area of Copano Bay on the mainland shore is a short beach, running into a bluff from 8 to 15 feet in height, with breaks of small marshy areas here and there, where grasses and sedges grow out in the water. The shore is composed generally of firm mud with shell in some spots. The Live Oak Peninsula shore is nearly all sand or finely broken shell. From Rattlesnake Point southward including the narrow, shallow cove known as Port Bay the shore is marshy.

Aransas Bay is deepest, 13 feet, in a small area in front of the town of Rockport (see map, Fig. 1). Radiating from this point it grows shallower, 8 to 9 feet deep, towards both ends and the shores. The mean depth of this bay, south of Ninemile Point, exclusive of the shore flats, is about 11 feet at mean low tide. North of Ninemile Point the open water area, exclusive of the region of oyster reefs, is 9 feet in depth. Near the upper end Aransas Bay is crossed at right angles by an irregular series of oyster reefs. Except for this part of the bay the bottom is composed of gray mud. At the south end the bay narrows down to Lydia Ann Channel, which is from 13 to 22 feet deep. This connects with Aransas Pass and thence the Gulf. Most of the shore of Aransas Bay is hard sand or fine shell, with marshy areas found in a couple of small coves, on Mud Island and on the small islands separating Aransas from Redfish Bay.

Aransas Bay gets its drainage from Copano Bay and the San Antonio and Guadalupe river basins by way of Mesquite, San Antonio and Espiritu Santo Bays to the northward. A small part of the Nueces River drainage may work into Aransas Bay at times, but this is probably negligible. The bay is sometimes greenish-gray in color after stormy weather, but it is usually green or bluish-green.

The Gulf Beach is a monotonous stretch of beach sand from Sabine Pass to Tampico. On Mustang Island sand dunes with sparse vegetation lie back from the beach 100 yards or more and the area in between, which is sometimes invaded by extra high tides, is composed of loose, generally blowing sands, and scattered bivalve shells, of which *Cardium robustum* is the most noticeable. The gradual-sloping, under-water beach is hard sand as far out as it can be waded. A series of three or more offshore underwater bars extending to several hundred yards offshore, become apparent as the rollers break over them during heavy surfs.

The offshore part of the shallow Gulf, explored by trawls off Aransas Pass out to the 10 fathom line, has a gray mud bottom, so far as the writer knows, but parts of it may be sand. Next to shore the bottom is sand.

III. Materials, Methods, and Organization of the Data

A. MATERIALS

For this work the Game, Fish and Oyster Commission boat K.T., a very sturdy work-boat, thirty-eight feet long, of the type used by shrimp trawlers, was used. It had a draught of four feet and was powered by a marine-type gasoline motor. Occasionally when faster trips were desired, smaller, faster cabin-launches of the type employed in patrol work were used. These boats and a cypress net-skiff, 15 feet long, such as that used by commercial fishermen on this coast, comprised the boat equipment. In this work I always had the help of one boat mate and sometimes two.

Specimens were collected in minnow seines, trawls, trammel nets and beach seines. The minnow seine was fifty feet long with reinforced webbing in the middle. The mesh was approximately one-third of an inch stretched. The trawl used was a regular otter trawl, such as is used in the shrimp fishery, except that it was somewhat smaller. It had a wingspread of 30 feet at the mouth and a mesh of 1½ inches stretched. A trammel net 1200 feet long was used with the net skiff. The depth of the net was 4 feet. The mesh was 1¾ inches stretched. On the Gulf beach a seine 300 feet in length was used. The mesh was 2 inches stretched and the depth of the net was 3 feet.

Water bottles, centigrade thermometers, measuring boards, a depth water sampler, a Nigretti-Zambra reversing thermometer and sea water hydrometers comprised the remainder of the equipment.

B. OPERATION OF NETS

The minnow seine caught larval fish down to 15 mm. long and crabs with a carapace width of 8 mm. A sweep was made beginning out in water of not more than 2 feet deep and thence to the shore with a short sweep up the shore as the net was brought in. The minnow seine used was heavily leaded at the bottom. Nevertheless, many fish escaped. At some stations escape was greater than at others, particularly where large shell was present. However, by and large the escape factor was constant haul after haul and can be ignored. The minnow seines catch the smaller fishes and other animals and usually only the smaller forms are present in the shallow waters where the hauls were made. Practically all specimens taken in minnow seines were the small species or smaller examples of the large species. Occasionally, a large mullet was taken.

The trawl was pulled in a circle behind the boat for 30 minutes at each station, after which the catch was pulled up on deck by hand. It was operated in the open bay and Gulf in water from 7 to 60 feet deep. The trawls are adapted to catching bottom forms, especially the young or small species and the sluggish larger fishes in turbid waters. The larger, swift fishes are never taken. A more complete discussion of the trawl as a collecting mechanism has been presented before (Gunter, 1936).

Trammel nets are made only for operation in shallow water. They are used for catching larger fishes commercially. This net was used only in the bays. A

trammel net is first put down as quietly as possible with the ends touching or very near to the shore, after which the fishermen go between the net and the shore with the skiff, and pole around making as much noise as possible. This is done by beating on the sides of the boat with the oars or tin cans and by splashing the water with the flat side of the oar. At times the bottom is jabbed hard with an oar. This process is called "drumming out a strike." It is effective and all species of fish except mullet usually streak for the deep water and thus become entangled in the net. On occasions fish will fail largely or in part to strike and this is especially true of certain species. From the beginning of the work until through January, 1942, the net used consisted of 900 feet of seine and 300 feet of trammel net. The seine was hauled in until the fish were in the trammel net. No appreciable differences in the catches were noticed when the gear was changed to 1200 feet of trammel net which was used from February, 1942, until the work was stopped.

The method of putting out the beach seine was for the operators to walk out together from the beach to water of about 5 feet depth and then pay the net out parallel to the shore. After it was paid out it was pulled straight in.

C. STATIONS

There were 3 trawl stations in Copano Bay, 4 in Aransas Bay, and 2 in the Gulf of Mexico.

Four minnow seine stations were visited in Copano Bay, 6 in Aransas Bay and 2 on the Gulf beach of Mustang Island. Four trammel net stations were set up in Copano Bay and 4 in Aransas Bay. There were 2 beach seine stations on the Gulf beach (Figure 1). This gives a total of 31 stations in all, which it was planned to visit each month. Due to breakdowns of the boat, bad weather and occasionally the press of other duties, the monthly program was not always completed, but it was followed as closely as possible.

All stations were numbered consecutively from the beginning in Copano Bay to the last station in the Gulf of Mexico and each haul was also numbered consecutively, such as minnow seine haul 1, minnow seine haul 2, etc. One hundred and seventy-eight minnow seine hauls, 109 trawl hauls, 114 trammel net hauls and 23 beach seine hauls were made. Table 1 shows the number of hauls made with each type of gear in the two bays and the Gulf each month.

Since sharp differences between catches of nearby stations with a given type of gear were not the rule and since analyses of the data on the basis of individual stations would be quite unwieldy and could only be presented in an inordinate number of tables, this method of handling the data was not used. The data on the numbers of fishes caught, total lengths, etc. were lumped together by bays or the Gulf for each type of gear used. For these reasons descriptions of individual stations are not presented.

All stations are indicated on the map. The minnow seine stations are labeled M. 1, etc., trammel net stations are labeled Tr. 1, etc., trawl stations are labeled T, 1, etc., and the beach seine stations are labeled B. 1 and B. 2. Occasionally in the text for the sake of brevity a given species is recorded as being caught at a given station.

In addition to the regular stations, on June 23 and 24, 1941, two minnow seine hauls were made on the Gulf beach of St. Joseph's Island. They were counted as regular hauls. In July, 1941, a beach seine haul was made 1 mile north of Corpus Christi Pass on Mustang Island. It was counted as a regular haul.

There is a shallow area along the margins of all shores. All commercial fishing except for shrimp trawling and pole and line fishing is done on these "flats" in Texas bay waters. The larger fish come out on the flats to feed and then they are caught in trammel nets or on trotlines. All pole and line fishing is also carried on here, except that done on oyster reefs. There are no nets used in Texas except otter trawls made for operation in deep water and these do not catch large fish, except for an occasional sluggish species, such as the rays. Offshore work was done only with the trawl.

D. HANDLING OF THE CATCH AND THE KINDS OF DATA COLLECTED

At each station all species of fishes and invertebrates were identified, divided into species lots and counted. Then the total length measurements in millimeters of 50 individuals of each species were recorded. If more than 50 examples of a given species were present, the remainder was only counted and the number recorded. Only the data on fishes are presented in this paper. The larger commercial fishes taken in the trammel nets and beach seines were opened and the gonadal condition examined. The stomach contents of several were examined. Specimens taken in minnow seines and trawls were measured in millimeters on a shrimp board, of the type described by Weymouth, Lindner and Anderson (1933). Specimens taken in trammel nets and beach seines were measured in half centimeters on a measuring stick.

It should be stated here that in measuring fish the writer always measured to the tip of the longest lobe of the tail bent down by the hand to put it in line with the body. This is the quickest way to measure a fish and when hundreds of specimens were on hand speed was essential. Fishes without a falcate tail were measured to the end of the longest ray of the tail fin.

The air temperature, water temperature and a sample of water were taken at each station. At trawl stations top and bottom water samples were taken with a depth water sampler and top and bottom temperatures were taken with a Nigretti-Zambra reversing thermometer. In the shallow water hauls the water was dipped up about one foot below the surface and the air and water surface temperatures were taken with centigrade thermometers reading in tenths of a degree. The air temperature was always taken in the shade. The turbidity of the water, as it appeared to the naked eye, the wind force and direction and general weather conditions and general state of the tide, whether high or low were always noted.

The water samples were later used in the laboratory for the determination of salinities by the specific gravity method. Hydrometers calibrated to compare sea water at 15° C. to distilled water at 4.0° C. were used. A corrective factor was added to make the readings equivalent to sea water at 17.5° C. compared to distilled water at the same temperature. Salinity determinations by this method are accurate enough for the purpose here where salinity variations were large. Only the water temperatures and salinities were used in compiling the data.

E. METHOD OF PRESENTING THE DATA

Since, as an introduction, a description of the monthly salinity and temperature characteristics of the waters during the time of the study will facilitate subsequent discussions, that topic is presented first. It is followed by the presentation of data for each individual species of fish, one by one, in the general order of the taxonomic or evolutionary scale, from the generalized to the more specialized. Discussion of the general topics are presented last.

For each fish a table was set up showing each haul in which the species was caught, the date, station, haul number, salinity, temperature and the number of specimens. This was necessary before the data on any species could be discussed and analyzed properly. There were 120 such tables and some were quite long. It was deemed unnecessary to publish them. Instead, the salient features brought out are presented in the discussion under the individual species. Tables showing the monthly catches of the most numerous fishes are presented. Since all the work was in one rather restricted region such a presentation is adequate for locality records of the commoner fishes. For species caught rarely the records are presented out-right with full data. When used, the stations are referred to by locality name or by number. The temperatures are always given in degrees centigrade and salinities in parts per thousand. For the sake of avoiding repetition, the words parts per thousand are often omitted. Fish caught in trawls came from the bottom and only the bottom salinities and temperatures were used in working up the data of trawl catches.

If a species was caught in adequate quantities, monthly total length-frequency curves were compiled from the original data sheets. These curves simply give percentages of the total number of the individuals at the various total lengths. Original data on total lengths were taken for most specimens in millimeters. The figures were tabulated for each haul, on tabulation paper, from the shortest to the longest. The numbers for each length were then thrown to the nearest 3 or 8, or, in other words, blocked off by groups of fives. The resultant figures for a given size for all hauls in a given month were added together. From these combined figures the percentages at each length were calculated for each month and plotted on millimeter paper with the lengths in millimeters on the abscissa and the per cents on the ordinate.

Only a few of the best curves are presented. The others were used in discussing the individual species, but they are only described and are not shown. Several species were not caught often enough for the construction of total length-frequency curves. For such species the data are briefly presented in the discussion alone or in the tables.

The highest and lowest salinity at which each species of fish was caught is given under the discussion of each species. In addition the salinity range was divided into blocks of five parts per thousand, for instance 0.0–4.9, 5.0–9.9, 10.0–14.9, etc., and the number of a species taken at each range was given. These data are given in table 4. The number of hauls with each type of gear at places where the salinity fell within a given range are shown in table 5.

IV. Hydrography

The temperatures and salinities were taken at too few stations and too irregularly with respect to time, for the construction of isotherm and isohaline lines. The number of readings, range of readings, and the averages are given for the two bays and the Gulf of Mexico, for each month, in tables 2 and 3. Every reading taken was used in the preparation of these tables. At trawl stations this included top and bottom temperatures and salinities. At shallow water stations only one reading was taken. Readers interested in the numbers of trawl and shallow water stations taken each month in a given locality are referred to table 1.

A. TEMPERATURE

The temperatures of the waters of the bays and shallow Gulf follow the air temperatures closely, as had been illustrated by Collier (MS). The water temperatures drop rather sharply from September to November and rise rapidly from March to May. The warmest months are June, July, and August, with very little differences in temperatures. Normally, the temperature begins to decline in September, but during the time of this work it did not do so. The cold months are December, January and February, with January the coldest for all bodies of water.

The average temperatures for both bays and Gulf for the warm months, June, July, August and September, were 29.86°, 29.40°, 29.80° and 28.90° C., respectively. This is on a basis of 169 readings. Probably year in and year out the average highest temperature is in July. For the four warm months, June to September, the average temperatures were found to be 29.86°, 29.93° and 29.14° C. for Copano Bay, Aransas Bay and the Gulf of Mexico, respectively, again on the basis of 169 readings. These readings include top and bottom temperatures at trawl stations.

Table 2 shows that in 1941 the highest average water temperatures in Copano Bay were found in August, while the following year they were found in June. The situation in Aransas Bay was just the reverse. In the Gulf the highest temperatures were found in August. The readings were not taken often enough in a given month to be completely dependable for monthly averages for the different bays. A circuit of a bay was made only once a month. Whether or not the skies were overcast made a difference in the temperature, especially in the shallow water near shore.

The highest temperature recorded was 34.9° C. It was taken in the shallow water of Aransas Bay in August, 1941. This is probably about as high a temperature as water on the open bay shore ever attains in this region, even on shallow flats. Water in coves and blind necks may attain higher temperatures. In the Laguna Madre, which has wider flats, the temperatures may go higher at times.

In December, January and February, the temperatures for both of the bays and the Gulf averaged 16.59°, 13.41° and 14.58° C., respectively, on the basis of 105 readings. Both top and bottom temperatures at trawl stations were used. The average bay temperatures for these winter months was 14.69° C. and the average

Gulf temperature was 15.35° C. Offshore hauls were not made in December and February. If they had been the Gulf temperature would probably have averaged higher than is shown here.

The average shallow water temperatures, as compared with top and bottom trawl station temperatures averaged 0.96°, 1.31°, and 0.21° C. higher during the summer for Copano Bay, Aransas Bay and the Gulf of Mexico, respectively. This was expected. It was not expected, on the other hand, that it would be still higher in the winter. This excess for Copano Bay and Aransas Bay in the winter was 2.90° and 2.13° C., respectively. There is no doubt that the shallow waters cool off faster and get colder than the open bay during northers, as is shown by the fact that mush ice sometimes forms on the shore (Gunter, 1941b), but they warm up faster, too, and the large number of days with sunshine probably accounts for the higher average temperatures of shallow water in winter.

The temperatures taken at trawl stations were most often higher at the surface, but part of the time they were lower and in still fewer cases the top and bottom temperatures were equal. In the four warm months there was no difference except in the third decimal place between the combined average top and bottom temperatures for the two bays, on a basis of 25 stations. In winter months, December to February, the surface for the bays averaged 0.02° C. warmer than the bottom, on a basis of 21 stations, which is not significant. The Gulf surface was 0.21° C. warmer than the bottom in summer, on the basis of 5 stations, while the bottom was 2.10° C. warmer in the winter, but the latter figure is only on the basis of 2 stations.

B. SALINITY

Table 3 gives the general salinity picture for each month for the area studied. The average monthly salinity of Copano Bay, Aransas Bay and the Gulf waters were, in that order, 9.1, 20.5 and 31.5 parts per thousand. Both top and bottom salinities at offshore stations were included.

Copano Bay had a more uniform salinity at any given time than did Aransas Bay. The latter always had a much lower salinity near Copano than it had near the Gulf.

The average salinity readings for the Gulf were often lower than that of sea water due to the fact that several of the readings were taken near the mouth of the pass where bay waters enter the Gulf.

A lag between the time of greatest freshness in Copano Bay and Aransas Bay and the Gulf can be seen by studying the table. For instance, Copano Bay water was very fresh from June to September, 1941, but the Gulf salinity did not fall perceptibly until September. This has been clearly shown by Collier (in MS).

Since in this paper we are interested specifically in the salinity and its relation to the fauna of the Texas Coast, I shall not discuss the relation of the bay salinities to the rainfall of the hinterland. This topic has been treated in detail by Collier (in MS), who had much more adequate data. It will suffice to say that the periods of low salinity followed periods of heaviest rainfall with a time lag. The time lag was less for Copano Bay. The year 1941 was one with more than average rainfall

(see Gunter, 1941c, and Price and Gunter, 1943). During June there was one rain of cloudburst proportions in the Rockport region.

It is interesting to note that the highest salinities found were in Aransas Bay in August and September, 1941, rather than in the Gulf of Mexico. This is not as surprising as it might first appear. Water on the flats of the shallow Texas bays has a high evaporation rate, which may quickly produce water having a higher salinity than the open sea. This is especially true of the Laguna Madre. The September sample was taken on a flat at The Cove, and the area was surrounded by water of lower salinity. The August sample was taken on the bottom in Lydia Ann Channel.

At trawl stations the salinity of the bottom was usually greater than at the surface. However, the reverse was true 6 times in 109 stations—too many times for it to be accounted for as an error. Collier (MS) found the same thing. The greater salinity of surface water at times must be due to turbulent currents about which little is known. The average surface salinities of Copano Bay, Aransas Bay and the Gulf of Mexico were 9.2, 20.0 and 32.8 per thousand, respectively while the average bottom salinities were 9.7, 21.7 and 36.1.

V. Data on the Various Species of Fishes

ELASMOBRANCHII. Sharks and Rays

EUSELACHII. True Sharks

Three species of sharks were taken. None of them were common, none were taken in the winter, and most of them were caught in the lower bay or open Gulf. In species names I have followed Springer (1938). Sharks are not very common in Copano or Aransas Bays. There are usually bottlenose dolphins, *Tursiops truncatus* (Montague), present in the bays and these mammals seem to be highly antagonistic to sharks (Gunter, 1942c). Possibly, they keep sharks out of the bays to some extent.

Carachariidae. Gray Sharks

Isogomphodon limbatus (Muller and Henle). Spot-fin Shark

One specimen, 130.5 cm. in length, was caught in a trammel net in lower Aransas Bay on June 17, 1941. The salinity was 11.1 per thousand. According to the data of Springer (1938), the shark was not quite mature. No food was contained in the stomach. Two stingaree spines were embedded in the body wall, projecting into the body cavity. No gut lesions were discovered, but the liver showed fresh punctures from the projecting spines. It is well known that sharks eat stingarees, apparently disregarding the spines. Gudger (1932, 1937) has shown that the spot-fin shark is a sting-ray eater and has recorded many instances of sharks with spines of rays embedded in their jaws.

Eight small specimens ranging in size from 32.5 to 44.0 cm. in length were taken in the Gulf at trawl station 8, August 30, 1941. The water temperature was 30.0° C. and the salinity was 36.7. These lengths are shorter than those of full-term embryos given by Springer (1938) as 54.0–57.0 cm. and possibly the identification of these small sharks was not correct. According to Mr. J. L. Baughman, this size falls within the range of *Carcharhinus natator* and possibly the little sharks belonged to that species.

Hypoprion brevirostris Poey. Lemon Shark

One specimen was taken in a trammel net in lower Aransas Bay on May 30, 1942. It measured 64.5 cm. in length. This is the same size as young freshly born in Florida on June 1 (Springer, *op. cit.*). The stomach was empty. The salinity was 32.4 per thousand and the temperature of the water was 28.4° C. This is the first record of this shark in Texas waters.

Sphyrnidae. Hammerhead Sharks

Sphyrna tiburo (Linnaeus). Bonnethead Shark

Springer (1938) has pointed out that there are probably more species of bonnetheads than have been recognized. The Texas shark seems to the writer to be different from the Florida shark figured by Springer.

Nine specimens of this shark were taken in the spring, summer and fall. One was caught in a trawl in the Gulf, 3 were caught in trawls and 5 in trammel nets in lower Aransas Bay. In addition there were 25 foetal young taken from 4 females. The temperature range of the water was from 24.0° to 29.4° C. and the salinity range was from 22.8 to 36.2. The data are given in table 6.

The size range of the bonnetheads was from 30.8 to 112.5 cm. in length. The two smallest specimens, 30.8 and 31.5 cm. long, were taken in September and October, 1941. It is to be noted that their sizes in relation to the date of capture would agree with the supposition that birth takes place in the late summer and early fall. They were almost the same size as 25 foetal young, 28.0 to 31.0 cm. long, taken the next year in August, and therefore it can be definitely assumed that the foetal young were nearing full-term. Individuals from each batch of foetal young were the same size. The four pregnant females were from 104.0 to 112.5 cm. long. They contained 4, 5, 8 and 8 young. The largest shark caught was slightly longer than the largest seen in Florida by Springer (1938) among several hundred specimens.

Springer has reported that in Florida crabs form a large part of the diet of the bonnethead shark. The six specimens opened here contained an average of 2.5 blue crabs, *Callinectes sapidus* Rathbun, in their stomachs.

BOTOIDEI. Rays

Five species of rays were taken. Only one, the stingaree, *Dasyatis sabina* (LeSueur), was common. The other four species were taken occasionally in waters of high salinity in the lower bay or Gulf.

Rajidae. Skates and Rays

Raja texana Chandler. Texas Clear-nosed Skate

Four specimens were taken in trawls 5 miles SSE of Aransas Pass in the Gulf of Mexico. One was caught January 12, two on March 22 and one on May 25, 1942. The salinity of the water ranged from 33.0 to 33.9. The temperatures ranged from 13.7° to 23.5° C. The first three skates ranged from 13.0 to 32.0 cm. in total length. The last specimen was only 58 mm. long and evidently was recently hatched from the egg. During the spring, puzzled fishermen sometimes bring to my laboratory the living eggs of a skate, which closely resemble the eggs of *R. texana* described by Springer (1939). Since *R. texana* is the only skate known to be in this area, I assume that the eggs belong to that species. This skate probably stays in water of high salinity. It was described by Chandler (1921) and the only other Texas record is that of Woods (1942).

Torpedinidae. Electric Rays

Narcine brasiliensis (Olfers). Torpedo

Twelve examples of this interesting electric ray were taken, all from the Gulf. They delivered only a weak shock after being brought up in trawls. The largest specimen was 308 mm. in length and was caught at trawl station 9, September 13,

1941. Two caught at trawl stations 8 and 9 on November 25, 1941, measured 287 and 115 mm. in length, respectively. The other nine examples were taken in one haul at trawl station 8, March 13, 1942. There were roughly two sizes. Four of them ranged from 178 to 222 mm. in length. Five of them ranged from 112 to 129 mm. in length. Individuals of the smaller group showed the same markings as foetal young figured by Bean and Weed (1911) and they must have been rather young. The temperature of the water where these rays were caught ranged from 15.4° to 29.5° C. and the salinity variation was from 30.6 to 36.5. Apparently the species likes water of high salinity. It is not taken in Texas inside waters except occasionally in the Laguna Madre, which is a peculiar environment with very high salinity at times.

Dasyatidae. Stingrays

Dasyatis americana Hildebrand and Schroeder. Southern Stingray

Six examples of this ray were taken. They ranged between 24.4 and 58.5 cm. in disk length. Three were taken in the Gulf and three were taken in Aransas Bay near the Gulf. The ray was caught in a trammel net. All others were taken in trawls. One ray did not have the small white spot on the forehead mentioned in the description of Hildebrand and Schroeder (1928). The temperature range of the water was 15.4° to 30.3° C. The salinity variation was from 28.5 to 36.2 per thousand. *D. americana* is much less common than the related *D. sabina* and so far as available information goes it is present in water of high salinity and inhabits the open Gulf or the parts of the bays near the passes.

Dasyatis sabina (LeSueur). Stingaree

This ray seems to be more common than all others put together on the northern shores of the Gulf of Mexico. Two hundred and forty-five specimens were taken in all, 3 in minnow seines, 22 in beach seines, 55 in trammel nets and 165 in trawls. Twenty-four were taken in Copano Bay, 122 in Aransas Bay and 99 in the Gulf. The monthly catches are shown in table 7.

The temperature at which *D. sabina* was caught ranged from 13.7° to 30.5° C. and the salinity varied from 2.2 to 36.7 parts per thousand. This ray is euryhalin, but table 4 shows that it was least common below a salinity of 10.0 per thousand and most common above a salinity of 30.0. Many authors have recorded it in fresh water (Gunter, 1942a) and I have shown that it may go up rivers for 200 miles (Gunter, 1938b).

Stingarees left Copano Bay in the fall and none were taken there in the months of November, December, January and February. They appeared again in March, 1942. None were taken in Aransas Bay in January, 1942, and only two in February, both in the channel leading to the Gulf. Seventy-six of the stingarees caught in the Gulf were taken from November to February. Fifty-four were taken in one haul a mile and a half outside the pass in November, 1941. The temperatures of Aransas Bay dropped from 25.9°–27.0° in October to 15.9°–16.7° C. in November and this large catch of stingarees is interpreted as a concentration of the rays which left the bays for the warmer Gulf waters with the onset of low temperatures in the fall.

The movement was not due to salinity drop for the salinity rose from an average 15.2 to 24.4 in Aransas Bay from October to November. It fell again the next month and the rays did not return.

It is concluded that the stingaree largely leaves Texas bay waters in the fall and spends the winter in the waters of the shallow Gulf and that this migration is probably due to temperature drop and not salinity change. The writer found (Gunter, 1938c) that stingarees were present throughout the year in Barataria Bay in Louisiana.

Not enough examples were taken to make length frequency curves for each month. Disk length of the rays varied from 13.0 to 46.0 cm. The smallest specimens were taken in the months of November and April in the Gulf and small specimens were taken in the spring, summer and fall and were not caught in December, January and February. The sixty-four rays caught in November, 1941, in the Gulf varied from 13.0 to 46.0 cm. in disk length. Forty-nine of them were below 25 cm. in disk length, but there was no frequency mode between that length and the lower limit of 13.0 cm. A long breeding season is indicated, with birth probably taking place throughout the spring, summer and fall. Stingarees were found breeding in mid-winter in Louisiana (Gunter, 1938c). Disk lengths were used because the tails of stingarees were often cut off. Specimens from 15.5 to 31.0 cm. in disk length were from 40.0 to 84.0 cm. in total length.

The stomachs of two specimens were opened. One was empty and the others contained Nereis-like worms.

Pteroplatea micrura (Schneider). Butterfly Ray

Two of these rays, measuring 197 and 193 mm. in total length, were taken August 30, 1941, 2 miles SSE of Aransas Pass in the Gulf of Mexico in trawls. Another measuring 219 mm. in length was taken on September 13, 1941, at the same place. The salinities were 36.7 and 36.5 and the temperatures were 30.0° and 29.5° C. In Louisiana the writer took one specimen in Barataria Bay in June, 1932, and another in the Gulf in September, 1932 (Gunter, 1935). These two examples were among 144,000 other fishes caught in trawls over a period of two and a half years. Apparently, this ray is not common on the western Gulf coast. Mr. J. L. Baughman says that this species is fairly common in the Gulf near Galveston.

OSTEICHTHYES (TELEOSTOMI). Bony Fishes

HOLOSTEI. Bony Ganoids

Lepisosteidae. Gars

Lepisosteus productus (Cope). Spotted Gar

Two spotted gars were taken at trammel net station 1, Copano Bay, on October 22, 1942. They were both males having developed testes and were 45.0 and 48.5 cm. in length. One contained an unidentifiable fish and the other was empty. The

temperature of the water was 25.8° C. and the salinity was 3.3 parts per thousand. Probably this fresh water gar only ventures in waters of very low salinity.

Lepisosteus spatula (Lacépède). Alligator Gar

The taxonomy of alligator gars is in an unsatisfactory state. This species may be conspecific with the Cuban alligator gar, *Lepisosteus tristoechus* (Bloch and Schneider).

Alligator gars are not uncommon in the bays especially around wharves of fish houses, where they must subsist to some extent on refuse thrown overboard. Twenty-two gars were taken in Copano Bay in trammel nets, 2 in Aransas Bay in a trammel net and 1 on the Gulf beach in a beach seine. They were caught in the months of September and November, 1941 and August, October and November, 1942. Seventeen fish were caught in October, 1942. The fish caught on the Gulf beach was unmeasured and unopened. The remaining 24 specimens were of 2 sizes. Twenty-one fish ranged from 60.0 to 92.5 cm. in length. Three specimens measured 132.0 to 159.0 cm. in length.

The salinity where alligator gars were caught ranged from 3.2 to 31.2. However, except for the fish taken on the Gulf beach, all were caught in water less than 12.5 parts per thousand saline and 19 specimens were caught in Copano Bay when the salinity varied from 3.2 to 4.6 parts per thousand. Table 4 shows the catch at different salinities. Although the alligator gar is euryhalin, it apparently prefers waters of low salinity.

Roe was found in the gars from September 29 to November 29, 1941. Two males with developing testes were found in October. George Powers Dunbar, cited by Weed (1923) said the eggs were dark purple and were laid during the months of December and January around New Orleans and the Lower Mississippi. Dunbar's observations were made a hundred years ago. Townsend (1928) gave the spawning time as May and June, but reported females distended with eggs in November.

Twelve of the 24 gars opened contained no food. Twelve gars contained 13 mullet, all probably *Mugil cephalus*, but not all could be identified.

ISOSPONDYLI. Soft-rayed Fishes

Elopidae. Tenpounders

Elops saurus Linnaeus. Bonefish or Skipjack

Fifteen bonefish were caught, 4 in Copano Bay, 10 in Aransas Bay and 1 on the Gulf beach. Nine were caught in trammel nets and 6 were caught in minnow seines. The size of specimens varied from 14.5 to 51.0 cm. in total length. The salinity of the water where the bonefish were caught varied from 2.5 to 32.0. Four fish were taken where the salinity was less than 5.00 per thousand. The water temperatures ranged from 28.4° to 30.6° C. The bonefish were caught in the months of June, July, September and October, 1941 and in May and June, 1942. According to commercial fishermen this fish does not enter the bays until spring and summer. Probably it does not enter the bays until the temperatures become high.

Two fish had eaten a peneid shrimp, one being definitely identified as *Penaeus setiferus* (Linnaeus). Another bonefish had eaten two perch, *Lagodon rhomboides* (Linnaeus). The other 2 specimens opened were empty.

Like its relative, the tarpon, this fish is a hard leaping fighter on the hook and for that reason is called skipjack by Texas fishermen. It is inedible, but it is perferred by some few fishermen who like to catch a small spectacular fighter on light tackle.

Megalopidae. Tarpons

Tarpon atlanticus (Cuvier and Valenciennes). Tarpon

The tarpon was taken only on two occasions. Large fish sometimes broke through the nets and probably some of them were tarpon. One fish was taken at Black Point, Copano Bay, July 28, 1941, in a trammel net. It was 101.0 cm. long and the stomach contained two small mullet (*Mugil* sp.). The temperature of the water was 29.0 and the salinity was 2.2. Another tarpon was taken at Rattlesnake Point, Copano Bay in a trammel net on September 29, 1941. It was 97.5 cm. long. The stomach contained an unidentifiable fish. The temperature of the water was 29.5 and the salinity was 10.6.

The commercial fishermen of the Texas Coast call the tarpon by the name of grand ecoy, which is a corruption of the Louisiana French name grande écaille.

Clupeidae. Herrings

Pomolobus chrysochloris Rafinesque. Blue Herring

On February 6, 1942, two specimens were caught in a beach seine on the Gulf beach of Mustang Island, one mile south of Aransas Pass. Each measured 26.5 cm. in total length. The salinity of the water was 29.3 and the temperature was about 16.0° C. This herring is more common to the eastward and is here probably near the southern extreme of its range. One specimen from the Colorado River at Austin was recorded in an unsigned article in Texas Game and Fish, vol. 1, no. 1, p. 10, 1942. Jordan and Gilbert (1882) recorded the species from Galveston Bay.

Opisthonema oglinum (LeSueur). Thread Herring

Three specimens were taken in trawl hauls in the Gulf on July 23, 1941, January 12, and April 22, 1942. The salinities ranged from 29.7 to 33.0 and the temperatures from 13.7° to 20.9° C. The temperature and salinity were not taken on the July haul. The total lengths of the fish were 194, 138 and 176 mm., respectively. The fish seems to be uncommon. It probably prefers waters of high salinity. It may be expected both in summer and winter.

Harengula macropthalma (Ranzani). Sardine

This little sardine was found to be present from April to November. Two thousand one hundred and forty specimens were caught in 23 minnow seine hauls and 40 were taken in 10 trawl hauls. Four fish were taken in Copano Bay, 343 in Aransas Bay and 1,836 in the Gulf, all but 25 of the latter being taken on the

Gulf beach. The fish was never found to be numerous in bay water, except for one minnow seine haul in Lydia Ann Channel, near the Gulf, on August 26, 1941, in which 279 fish were taken. The greatest abundance was that of young fish in the surf of the Gulf beach, where they apparently grew from larvae to sub-adult or adult fish. Table 8 summarizes this information. The largest specimens were taken in the open waters of the Gulf in trawls. Possibly they avoided the minnow seine. All small fish were taken on the shores of the lower bay or Gulf. Nevertheless, the largest fish were taken in waters of higher salinity. Although the salinity ranged from 4.8 to 36.9 the fish was found mostly in waters of high salinity and only 16 specimens were taken in water less than 25.00 parts per thousand salt. Table 4 shows the catch at various salinities.

The temperature of the water where this species was taken ranged from 20.5° to 30.5° C. Only 9 specimens were taken in water less than 24.0° C. in temperature. When the temperature dropped below that figure the fish soon vanished from the catches. Whether the fish merely leave the close proximity of the shore or go southward is not known. However, none were taken in the trawls a mile and a half and five miles offshore from November to March inclusive.

Total length-frequency curves were made but they are not presented. Fish with a total length-frequency mode at 33 mm. were taken on the Gulf beach in June, 1941. They were probably spawned in April. This mode lay between 63 to 78 mm., apparently due to growth of the population, in August. A few stragglers, 150 to 168 mm. in length, were taken in trawls in the Gulf at the same time. In September a new group came in with a mode at 23 mm. A small number of fish from 70 to 150 mm. still remained. These small fish were only postlarvae and apparently there were two spawning periods in the warm months. They remained through October and three stragglers, between 33 and 68 mm. long, were taken in November. After that the fish disappeared. Routine work was not started on the Gulf beach until June, 1941 and whether the fish were present before is not known. They reappeared in trawl hauls in the Gulf in April, 1942 but were not taken in May in trawls, nor were they caught that month in Aransas Bay. No hauls were made in July and the fish were present on the Gulf beach in August. During that month they ranged in size from 23 to 83 mm. in length, with a total length frequency mode at 38 mm. In September another group came in with a mode at 27 mm. and no fish above 55 mm. long was caught. The curve for September was very similar to that of the year before. Only 9 sardines were caught in 2 minnow seine hauls on the Gulf beach in October, 1942, and in November none were caught. This completed the cycle comparable to the previous year, but the fish disappeared a little earlier. No fish were taken in Aransas or Copano Bays in August, 1942 as in the previous year. Although the data for the second year were incomplete, there was a difference in the time of appearance of the fish. In this connection the monthly changes in abundance as shown in table 9 deserve consideration. This shows that on the Gulf beach the fish become increasingly abundant to September and was less abundant in earlier months. That the fish was present in the spring and early summer months of 1942 is shown by the 9 specimens caught in trawls in the Gulf in April and the 2 caught in Aransas Bay in minnow seines in June. The temperature of the water

on the Gulf beach was 29.0° C. in June, 1942, well within the temperature range at which the fish was taken in other hauls, so temperature was not the factor that kept the fish off the beach in that month. Possibly the fish was simply not common enough to be taken on the Gulf beach in the earlier months, although it showed up in greater abundance than ever in August and September.

Longley reported (Longley and Hildebrand, 1941) that this fish was common in summer at Tortugas, with adult fish 155 to 193 mm. in length not quite reaching sexual maturity in June. On the south Texas Coast sexual maturity comes earlier as shown by the appearance of young in both years in June. Dr. Longley's observations would coincide with ripening for a second spawning season such as was indicated for the fish in Texas.

Summary: Two thousand two hundred and four specimens of this little sardine were taken from April to November. It was taken in waters of high salinity, chiefly on the Gulf beach, with only stragglers getting back into Copano Bay. The greatest abundance was attained in the fall. The appearance of post-larval young twice during one summer suggests that there are 2 spawning periods a season or at least 2 spawning peaks.

Brevoortia sp. Menhaden

The long accepted status of the menhaden of the northern Gulf of Mexico has been that there was one species, *Brevoortia patronus* Goode, or *B. tyrannus patronus* Goode, as some authors would have it. The writer suddenly became aware after some months work on the Texas Coast that 2 species of *Brevoortia* were present. One species was found in more saline waters, had more green on the back and was consistently more slimy than the other. A cursory examination has led me to believe that it does not differ from the Atlantic *B. tyrannus* (Latrobe) and it is referred to below under that name. The second species was much more common, lived in waters of lower salinity, was more silvery and had less green color, had a sharper snout and a different shaped head, had much smaller scales and was not slimy. This may be the original *B. patronous* of Goode but it seems to me to be rather close to or possibly identical with the *B. smithi* of Hildebrand (1941). Dr. Hildebrand is at present engaged in revising this group of fishes and for the present the common brackish water menhaden of Texas will be referred to as *Brevoortia* sp.

This account is based only on fish taken in Copano and Aransas Bays. They were known to belong to the species here called *Brevoortia* sp. One group of 142 fish taken in one minnow seine haul on the Gulf beach, at the mouth of Cedar Bayou Pass, June 1941, probably belonged to this species, but the writer is not certain and they are excluded.

Table 10 shows that 1,281 fish were caught in both bays, 66 per cent of them from Copano Bay. Total length measurements show that the smallest fish were taken in Copano Bay. This is also shown in table 10, when it is remembered that the smallest fish were taken in minnow seines and the largest in trammel nets. Only 5 specimens were taken in trammel nets in Copano Bay, during September, 1941, and March and April, 1942. Specimens were taken in trammel nets in Aransas Bay every month except September and December, 1941, and January, 1942. Fish

were taken in minnow seines in Aransas Bay only in April and May, 1942, whereas in Copano they were taken from February to August, 1942. Specimens were taken in trawls every month in both bays, except for March, April and May, 1941 in Aransas Bay. Hauls were just beginning then and may not have been comparable to later work.

The temperature range where *Brevoortia* sp. was caught ranged from 9.1° to 31.0° C. The salinity ranged from 2.0 to 33.7 per thousand. The species is probably completely euryhalin. Specimens ranged in size from 15 mm. to 313 mm. in length. No fish greater than 168 mm. in length was caught in water of salinity less than 4.9 parts per thousand and none less than 60 mm. in length was caught in water with a salinity greater than 30.0 parts per thousand. Some relation between the size of the fish and salinity of the water exists.

Brevoortia sp. is a plankton-feeder and it may be seen in schools twisting and turning through the water, with mouth agape, as I have described before (Gunter, 1938c). The fact that many fish were taken in trawls, even in the deeper bay (Aransas), indicates that the fish spends part of the time near the bottom. Many fishes including plankton-feeders, spend much time near the bottom in shallow coastal waters (Gunter, 1941a).

Monthly total length-frequency curves for specimens from both bays were made. They showed that the size of fish from Copano Bay was smaller than fish from Aransas Bay. This is also shown in table 11. In December and January when very few fish were caught in Copano Bay they were taken in greater abundance in Aransas Bay. The size of fish in that bay decreased from November to January, due, it is concluded, to smaller fish coming in from Copano Bay, since they were not known to be present elsewhere. These facts are strongly suggestive of a general midwinter exodus of *Brevoortia* sp. from Copano Bay. From October to January the larger fish left Aransas Bay, or at least they were not caught. The most important point shown by the total length-frequency curves for both bays was the appearance of the post-larval young, from 21 to 30 mm. in length, in February, 1942 in Copano Bay. They could be followed until July when they were from 25 to 45 mm. long. A few appeared in upper Aransas Bay in April and May. This is rather strong evidence that spawning took place in Copano Bay (waters of low salinity).

A male, 12.5 cm. long, exuding milt was taken on February 25, 1942 at Frandolig's Point, upper Aransas Bay. A ripe female, measuring 15.0 cm. in length, was taken at Rattlesnake Point, Copano Bay, March 29, 1942. The salinities were 12.8 and 13.1 and the temperatures were 10.5° and 14.0° C., respectively. These were the only ripe adults seen, but specimens of this fish were not opened. Spawning probably extends from midwinter to early spring.

Combined total length-frequency curves for both bays were made. In April, 1941 the only group of menhaden caught were from 88 to 133 mm. long with a mode at 113 and 118 mm. This group persisted until October when it was from 128 to 173 mm. long. In August a second group from 88 to 103 mm. long appeared, which became predominant in November and December. Remnants of the two groups persisted through the winter until May when they became more numerous again.

At that time the smaller group had a mode at 128 to 133 mm. Post-larvae came into the catch in January and they were predominant from then until May, when their size ranged from 23 to 43 mm. in length. A small number of fish over 200 mm. long were taken every month except April, May, August and September, 1941 and June and August, 1942. Fish above 300 mm. long were taken only in the months of June and October, 1941 and February, 1942. Fish above 200 mm. long were numerous only in February and March. The curves indicate that this menhaden attained a length of from about 88 to 113 mm. at the age of one year.

It was observed that schools of *Brevoortia* sp. swimming about in the water were of a size, and the same thing was noted in many catches. The fact that certain schools or sizes may have been missed in the sampling seems to be the most reasonable explanation of such cases as the absence of the group with a modal length at 100 mm. from both bays in October, 1941 while it was present in both the preceding and following months.

Table 10 gives some indication of the seasonal variations in abundance, so far as it could be determined by the sampling. There was a peak of abundance in both bays in April, 1942. June and July seem to be months of scarcity of the species in both bays. A low point in numbers was reached in December and January in Copano Bay while there was a rise in numbers in Aransas Bay at the same time. Coupled with the information furnished by the length-frequency curves for both bays, discussed above, this is strong evidence for a midwinter exodus of the fish from Copano Bay into Aransas Bay. The midwinter abundance peak for the latter bay also duplicates what was found in Barataria Bay, Louisiana (Gunter, 1938c) for three successive winters. In that paper the menhaden was called *Brevoortia patronus* Goode and probably comprised the two species discussed here with *Brevoortia* sp. predominating. The scarcity of fish in June and July found there also corresponds with what was found in Texas. The conclusion (*op. cit.*, p. 336) that the midwinter abundance peak was formed by fish spawned the previous fall seems to be erroneous. The fish were probably a year old. The statement was made (*loc. cit.*) "that there is an abundance peak for this fish in the bay, during the winter, which is characteristic of the life history of the species." This applied to trawl catches. There is evidence that the same statement applies in Texas to the bay segment next to the Gulf, that is to say the coastal lagoon.

Summary: One thousand, two hundred and thirty-one fish were caught, 66 per cent in Copano Bay and the remainder in Aransas Bay. Small fish were taken in less saline water and the larger fish were taken in saltier water. Post-larval young appeared in Copano Bay in January and February. A ripe male and female were taken in February and March. Fish largely left Copano Bay in midwinter and went into Aransas Bay.

Brevoortia tyrannus (Latrobe). Atlantic Menhaden

Twenty-two specimens of fish thought to be *Brevoortia tyrannus* (Latrobe) were caught in the Gulf in trawl and minnow seine hauls. The trawl catches were made in the months of August to November, 1941 and March and April, 1942. The fish caught ranged from 110 to 211 mm. long. The minnow seine catches were

made in the months of March and April, 1942. The size of the fish caught ranged from 28 to 59 mm. Eight fish were caught in minnow seines. The fish also comes into bay waters as far up as Ninemile Point in Aransas Bay, but it was noted before difference between the two species of *Brevoortia* was clear, and the data are not presented. For that reason the exact temperature and salinity ranges found are not given. This menhaden was found to be less common than *Brevoortia* sp. and found in saltier water. Several clupeid larvae tentatively identified as *Brevoortia* were taken in minnow seines on the Gulf beach in March and April, 1942. They were not measured. Small specimens were also taken at the same time, as noted above. Since they were separated by many miles from the young of *Brevoortia* sp. in Copano and upper Aransas Bays, the most reasonable supposition is that they were *B. tyrannus*. Additional work will be necessary to clarify the point.

It is possible that there was some confusion between *Brevoortia* sp. and *B. tyrannus* (Latrobe) in Aransas Bay and Gulf of Mexico, which can only be resolved by future work after the taxonomy of the Texas *Brevoortia* is clearly worked out. The chief points brought out in this study are that there are 2 species of menhaden on the Texas Coast. One, *Brevoortia* sp. is a brackish water species, spawning in the back bays, while the other, *B. tyrannus* lives mostly in water of greater salinity along the sea coast proper and the young apparently first appear on the Gulf beach.

Dorosomidae. Gizzard Shads

Dorosoma cepedianum (LeSueur). Gizzard Shad

Some authorities hold that there are two subspecies of this fish on the Texas Coast, the other being *Dorosoma cepedianum exile* Jordan and Gilbert. This latter subspecies may not be valid and furthermore since no fish were seen that did not fit the description of *D. cepedianum*, all were listed under that name.

Six hundred and ninety-two gizzard shad were caught, 402 in trawls, 289 in trammel nets and 1 in a minnow seine. Six hundred and twenty-three fish were caught in Copano Bay and 69 in Aransas Bay. Table 12 gives the monthly catch. Specimens were taken in every month of the year, in waters varying from 2.0 to 33.7 parts per thousand salt.

This fish inhabits most of the eastern waters of the United States as far north as Ohio and Illinois. It spawns in fresh water. It also inhabits the brackish coastal waters from Cape Cod to Mexico. It is a euryhalin, fresh water fish. Whether or not all fish that have access to the sea migrate there in the young stages is not known, but many are landlocked. On the other hand, fish that go to the sea coast must return to fresh water to spawn. Therefore, it may be said that part of the population is anadromous. An upstream migration of large individuals in the spring, noted in the Mississippi at New Orleans (Gowanloch, 1933), is probably a spawning migration.

D. cepedianum prefers brackish water to full salt water, as shown by the fact that 90.2 per cent of the catch was in Copano Bay. Only 9.0 per cent of the fish were caught in water above a salinity of 18.0 parts per thousand saline. Only 0.9 per cent of the fish were taken in water with a salinity of over 25 parts per thousand and only one specimen was taken in water above 30.0 parts per thousand salt. Table

4 shows that over half the fish were taken between salinities of 10.0 and 14.9. However, a greater number of catches were made at those salinites. When the numbers of all hauls made within the salinity groups were divided into the number of fish caught, giving the average catch of hauls within a salinity group, it showed that there is no discernible distributional difference in numbers of the fish between 0 and 15.0 parts per thousand salt, while above that the species was caught much less often and less and less as the salinity became greater.

For the purpose of determining the relation between the size of the fish and the salinity of the water, total length-frequency curves were plotted for all fish taken in water within a given salinity grouping, regardless of season or locality. The groupings were by 5 parts per thousand salt starting with zero. Figure 2 shows the results. The smallest fish were taken in the freshest water and the size of the fish increased as the salinity increased. This is a general and not an absolute relation, for the largest specimens were not taken in the saltiest water.

Monthly total length-frequency curves for each month show that the size of gizzard shad caught increased gradually from June, 1941, to January, 1942. Table 12 gives a summary of the data on total lengths. So far as the data go they show that the smaller fish appeared in the bays in the summer from June to August. The greatest number of fish was taken in October and November, 1941. The table also shows that there was a sharp drop in the catch in February, 1942, and the small catch continued until the work was discontinued. The reason for this decline in abundance is unknown.

A ripe female 228 mm. long was taken April 20, 1942 in Copano Bay.

Summary: Six hundred and ninety-two gizzard shad were caught in water ranging in salinity between 2.0 and 33.7 per thousand salt. Fish were caught in greatest numbers in water between 0 and 15.0 parts per thousand salt. Most of them were taken in Copano Bay. The smallest fish were found in the freshest water and size increased from June, 1941 to January, 1942. The smallest specimens were found only in the summer. A ripe female was taken in April, 1942. No gizzard shad were found in the Gulf of Mexico.

Signalosa mexicana (Günther)

The taxonomy of this genus is in an unsatisfactory condition. The specimens taken were all of the same species, so far as could be determined, and they are referred to provisionally as *Signalosa mexicana.*

Two-hundred and twenty-nine specimens were taken, all in trawl hauls. Fish were taken in Copano Bay every month from July, 1941 to May, 1942, inclusive, with the exception of December and April. The number of fish varied from one taken in November to 15 taken in February. In Aransas Bay the fish was caught every month from July, 1941 to February, 1942. The number caught each month varied from one taken in July and December to 113 taken in August. The months of August and October were the months of largest catches of this gizzard shad. Thirty-six fish were taken in Copano Bay and 193 in Aransas Bay. The fish probably spawns in this region, but none of the young were taken and no fish were taken near shore in minnow seines. Possibly the whole life cycle is completed in offshore

waters of the open bay. However, the trawls can catch smaller shad than any taken in this study and the possibility remains that spawning and early growth may take place in fresh water. The size range of specimens caught was 61 to 168 mm. in length.

The temperature range at which the fish was caught was from 9.1° to 30.1° C. and the salinity was from 3.8 to 26.9 parts per thousand salt. Only 6 specimens were taken in water above 25.0 parts per thousand salt and only 3 were taken in water less than 5.0 parts per thousand salt. Ninety-two and three-tenths per cent were taken in salinities between 10.0 and 20.0. Table 4 gives the data. Apparently the fish prefers water that is neither fully marine nor very fresh, such as is found most of the time in the lagoonal portion of the Texas Coast. There was a relation between the size of specimens and the salinity of the water in which they were caught, the larger fish being taken in waters of higher salinity and the smaller specimens in water of lower salinity. This is shown in figure 3.

Monthly total length-frequency curves, not presented, show that there was an increase in size of the fish between August and November. Not enough specimens for making curves were taken in July and December. In August the fish ranged from 77 to 135 mm. in length with a mode at 103 to 108 mm. In November the fish ranged from 98 to 140 mm. long with a mode at 118 mm. The stragglers taken in August and September fell in this size group. No other size groups were present at this time. In January fish from 61 to 86 mm. long came into the catch with a mode at 63 mm. and no other fish were taken. The same group was present in February, along with a few fish 114 to 117 mm. long. Two fish 68 and 73 mm. long were taken in March. Afterwards no more fish were taken except for 3 larger ones, 119 to 139 mm. long, caught in May. A similar influx of young in winter was noted before for *S. atchafalayae* in Louisiana (Gunter, 1938c).

Engraulidae. Anchovies

Anchoa hepsetus (Linnaeus). Anchovy

In his recent revision of the American anchovies Hildebrand (1943) has separated this species into 2 subspecies, *Anchoa hepsetus hepsetus* (Linnaeus) and *A. h. colonensis* Hildebrand, which he says integrades along the Gulf Coast of the United States, but are well separated in Panama. The subspecies are hard to separate in the adult stage without detailed examination, which was not possible in the field. Intergradation in this region would make the task even more difficult and the fact that sub-adult fish are dealt with complicates it further. Therefore, I have referred all specimens to the specific name only. It is my impression, however, that most of the specimens conformed with *A. h. hepsetus* in that they possessed a broad stripe in contradiction to *A. h. colonensis*, which has a narrow stripe.

One thousand two hundred and eighty-three specimens were taken in all, 1,210 in minnow seines, 67 in trawls and 6 in beach seines. Forty-one fish were caught in Copano Bay, 63 in Aransas Bay and 1,117 in the Gulf. Table 13 shows that this anchovy was taken in Copano Bay from July to September. In Aransas Bay and the Gulf the fish was caught from April to November, with a single record in January. The fish is practically absent from the bays and shallow Gulf waters in the winter.

Hildebrand and Schroeder (1928) found no specimens in the winter months in Chesapeake Bay. The records of *Anchoviella epsetus* taken in the bays after a hard freeze (Gunter, 1941b), were erroneous. The fish was *A. mitchilli.*

The species was taken at temperatures ranging from 8.1° to 32.0° C., although, with the exception of the single winter specimen, none were taken at temperatures less than 20.5° C. Specimens were taken at salinities ranging from 2.5 to 36.9 parts per thousand, but only 3.0 per cent of the fish were taken in water less than 15.0 parts per thousand saline, as shown in table 4. Figure 4 shows that the largest fish were taken in the saltiest water.

Specimens ranged in size from 29 to 141 mm. in length. Monthly total length-frequency graphs were drawn, but are not presented. They show that two chief size groups were present. In June, 1941 a small size group was caught ranging from 33 to 53 mm. in total length. Some fish as small as 28 mm. long were taken in July and August. This group persisted until November, when its length range was from 43 to 83 mm., with a mode at 48 to 53 mm. Only one fish was caught in December. It was 48 mm. long. After that the group disappeared and did not come into the catch again until June and July, when 14 specimens from 33 to 53 mm. long were caught.

A less numerous larger size group, ranging from 113 to 143 mm. long, was taken in the months of July to October, 1941, and April and May, 1942. During the latter two months it was the only fish caught. A few stragglers intermediate between these two size groups were taken in August, September and October.

Two females 113 and 118 mm. in length, with developing gonads were taken on the Gulf beach in April, 1942. Two females 130 and 132 mm. in length and 4 males ranging from 129 to 141 mm. in length, all with well developed gonads, were taken 5 miles out in the Gulf from Aransas Pass in May, 1942.

Anchoa lyolepis (Evermann and Marsh). Anchovy

This anchovy is uncommon in Texas coastal waters. Six specimens were caught, all in minnow seines. One specimen was taken July 5, 1941, on the Gulf beach of Mustang Island and 5 more were taken in Lydia Ann Channel, lower Aransas Bay, on August 26, 1941. The size range of specimens was from 46 to 51 mm. in total length. The temperature at both hauls was 28.0° C. and the salinity was 35.6 and 36.4 per thousand, respectively.

Hildebrand (1943) states that museum collections of this species from the United States all come from trawl hauls some distance offshore in the Gulf of Mexico. This indicates that the fish lives in waters of high salinity. Hildebrand gives the range of the species as the West Indies, Gulf of Mexico and Gulf of Venezuela. The fish is more common in the West Indies than in Texas waters.

Anchoa mitchilli diaphana Hildebrand. Bay Anchovy

Hildebrand (1943) has divided the species formerly known as *Anchoviella mitchelli* (Cuvier and Valenciennes) into 2 subspecies, *Anchoa mitchilli mitchilli* (Cuvier and Valenciennes) and *A. m. diaphana* Hildebrand. The known range of the former is from Massachusetts to North Carolina, while the range of the latter

is from South Carolina to Yucatan, but not in the West Indies. The Texas fish corresponds with Dr. Hildebrand's description of *A. m. diaphana.*

Eleven thousand and fifty-four specimens were taken in the course of this work, 4,699 in trawl hauls and 6,355 in minnow seines. A few were picked up in large nets. Four thousand nine hundred and twelve fish were caught in Copano Bay, 4,722 in Aransas Bay and 1,420 in the Gulf of Mexico. The numbers of this anchovy in the shallow coastal waters are enormous. It was taken in trawls and minnow seines in all bay waters, at all times of the year at temperatures ranging from 8.1° to 33.2° C. and salinities ranging from 2.3 to 36.9. The average catch in trawl and minnow seine hauls was Copano Bay 51.2, Aransas Bay 36.6 and the Gulf of Mexico 24.1. It was more abundant in the bays than in the shallow Gulf. Table 14 shows the monthly catch.

This species is known to be euryhalin and table 4 shows the numbers taken at various salinities were not significantly different, except that more fish were taken on an average in hauls at salinities less than 5.0 parts per thousand salt. The young were found in waters of both high and low salinity and although there was some relation between size distribution of the fish and salinity of the water, the relation was not as pronounced as for certain other species of fishes. Fish taken between salinities of 2.3 and 19.9 ranged from 18 to 93 mm. in length and had a total length-frequency mode at 43 mm. Fish taken at salinities above 20.0 ranged from 23 to 83 mm. long and had a mode at 48 mm. There was also a larger proportion of fish from 48 to 73 mm. long in that group than in the other group.

It is necessary to interject a word of caution concerning the data on small anchovies. Small anchovies are difficult to identify and, although this was held in mind during the course of the investigation, I am not sure the identification of young individuals may have been erroneous in some instances. More careful attention to the biology of the anchovies would have necessitated the neglect of some other species and abandonment of the broad aims of the work. Since it is probable that this type of work will not be repeated for a long time on the Texas Coast it was thought best, nevertheless, to present the data with the understanding that they are tentative so far as small anchovies are concerned.

Gonadal examinations of this anchovy were not made in 1941. The first bay anchovies with developing gonads were noted in Copano and Aransas Bays in the last of March, 1942 and fish were taken with ripe and developing gonads, in both bays and the Gulf, from then until the trawl and minnow seine hauls were terminated in August. The March temperatures are similar to those of November and early December and a very long breeding season is indicated. Examination of the gonads was made by mashing the forepart of the fish, whereupon the testes or ovaries were extruded from the abdominal cavity at the anal region. With most males the testes came out unruptured, while usually the eggs of the females were stripped from the ovaries. One-hundred and twenty-six males and 122 females were examined. The smallest male with developing testes was 37 mm. in length and the largest found was 87 mm. in length. The smallest female with enlarged ovaries was 36 mm. in length and the largest was 91 mm. in length. Mature and maturing males averaged 56.3 mm. in length while mature and maturing females averaged 60.0 mm. in length.

Monthly total length-frequency curves for both of the bays and the Gulf of Mexico were not particularly illuminating, except that they showed small fish in all three localities. Therefore, the curves for all three bodies of water were combined and presented in Figure 5. There seem to be 2 year-classes of fish present all the time and with possibly 3 present at times. Small fish were present in least numbers from March through June. Small fish were present through December and January, another indication of a long breeding season. The absence of smallest fish in the spring indicates that spawning did not take place during the winter months. Table 14 shows that this anchovy was most abundant in July, 1941 in Copano Bay and in February, 1942 in Aransas Bay. There are indications that June is a time of low abundance. The table also indicates that the fish is most common in the Gulf in the winter and spring and is scarce there in summer. Apparently, there is a general movement from shallow to deeper water in the winter.

Summary of the anchovies: Three species were found on this part of the Texas Coast. A West Indian species, *Anchoa lyolepis,* was very rare. *Anchoa hepsetus* was most common in waters of high salinity (Gulf waters) and was practically absent in winter. There was a slight direct relation between increased salinity of the waters and the size of specimens caught. Fish with ripe gonads were found in April and May. *Anchoa mitchilli diaphana* was the most abundant species, being present in enormous numbers, and more abundantly in the bays than in the Gulf. Little relation between the salinty and the distribution of this anchovy with respect to abundance was found. There was some slight indication of a relation between the salinity of the environment and the size of specimens in that a few more large specimens were taken in saltier water than in fresher water. There are indications that this anchovy has a very long breeding season, probably extending from spring to fall. One-hundred and two anchovies were not identified.

EVENTOGNATHI. Carps

Catostomidae. Suckers and Buffalos

Ictiobus bubalus (Rafinesque). Smallmouth Buffalo

Three specimens were taken in a trammel net at Black Point, Copano Bay, near the mouth of the Aransas River, February 17, 1942. They measured 21.5, 32.5 and 48.0 cm. in length. The salinity of the water was 2.3 and the temperature was 15.5° C. This fresh water species comes down to the edge of salt water and is therefore sometimes present in the upper bays after heavy rains. Buffalo are sometimes numerous enough in the upper Trinity Bay, East Texas, to be fished for by commercial fishermen.

NEMATOGNATHI. Catfishes

Ariidae. Marine Catfishes

Bagre marina (Mitchill). Gafftopsail Catfish

This fish is used for food and during the years 1935 to 1942 an average of 11,510 pounds have been sold annually by commercial fishermen on the Texas

Coast (see Ann. Rept., Game, Fish and Oyster Comm. 1934–35, 1936–37, to 1941–42).

Eight hundred and seventy-two gafftopsails were caught in this work, ranging in size from 78 to 475 mm. in length. Two hundred and seventy-six fish were caught in Copano Bay, 563 in Aransas Bay and 33 in the Gulf of Mexico. Only 9 fish were caught in large nets. The others were caught in trawls. The average catch for both types of gear was 2.8 in Copano Bay, 5.4 in Aransas Bay and 0.8 in the Gulf of Mexico.

The salinity where the fish were caught ranged from 3.7 to 33.9 per thousand. Table 4 shows the numbers of fish caught at the various salinities. It indicates that most of them were taken between a salinity of 5.0 and 30.0 per mille. Above and below this salinity range the average catch was less. The fish seems to be an estuarine species preferring intermediate salinities. However, it doubtless enters water of higher salinity in winter as explained below.

Table 15 shows that the fish was caught from March to November, with no fish recorded from December to February. Table 16 was prepared from the statistics given in the annual reports of the Game, Fish and Oyster Commission, cited above. It shows that in the majority of years the gafftopsail was unreported in December, January and February. Presumably this catfish, which is a subtropical species, largely leaves the coastal area during winter. Storey (1937) has shown that this species is very sensitive to cold and is often killed when cold waves strike.

There seems to be little correlation between the salinity of the water and the size of specimens caught, except for some slight differences shown by the total length-frequency curves of fish taken in water below 5.0 parts per thousand salt, as compared to curves for fish taken in higher salinities. The differences are not conclusive, however, and the curves are not presented.

According to the figures of the commercial catch on the Texas Coast, corroborated by my own data, *Bagre marina* is practically absent from bay waters in the winter, but returns in the spring. The commercial catch indicates that the adults are present in greatest numbers in March, April and May, with April as the peak month. Although there is no doubt of a large influx of gafftopsails into the bays in the spring, the decline in the commercial catch in the summer may be in part the result of decrease in fishing effort, which is more intensive in the spring. On the other hand the most intensive fishing is done in the winter when few or no gafftopsails are reported.

The males of many ariid catfishes carry the eggs in their mouths where hatching takes place. The young fish, which are quite helpless with the large ball of yolk attached, are also carried for a time. Although there had been some previous fragmentary observations, the status of *B. marina* as species having oral gestation was first fully established by Gudger (1916, 1918). Gudger (1918) stated that breeding takes place within a few days time during the latter part of May, at Beaufort, N. C. He estimated that the period of gestation was from 60 to 70 days. Possibly breeding takes place earlier in Texas waters. Gudger (*op. cit.*) states that the young are liberated when at about the length of 85 mm. and above. I caught free-swimming young 78 mm. long and I am inclined to believe the size at liberation

may be slightly less than Gudger's figure. I took only one gestating fish. It was caught in lower Aransas Bay, near the channel leading into the Gulf of Mexico on June 17, 1941. The salinity of the water was 11.1. Twenty-seven young measuring 75 mm. in length were contained in the mouth. In the light of Gudger's calculations this would indicate that the breeding period was in early May.

Only 9 large gafftopsails were caught and most of the specimens were small fish taken in the trawls. Table 15 shows that the greatest catch was in August and September, as would be expected from liberation of the young in July followed by their gradual movement into waters of the open bay. Fish taken in July were obviously freshly liberated. They ranged in size from 78 to 100 mm. in length. They grew rapidly and in November ranged from 113 to 193 mm. in length. Long before the curves were worked up, general observation indicated that the same group of fish were being caught from month to month. In December the fish all disappeared. In April, the same group apparently returned to the bays at a size of 158 to 203 mm. in length. In August, 1942, another group was caught that was comparable in length to fish caught in the previous August. They were 103 to 143 mm. long. No fish were caught in the Gulf until October in 1941 and it may be said that the fish grew up in the bays. In October they began to enter the Gulf and in November were found there alone, prior to complete disappearance in December.

The stomachs of eight fish, ranging in size from 280 to 475 mm. long, were examined. Three were empty. The other five all contained blue crabs, while in addition one fish contained a large grasshopper and another contained a shrimp, *Penaeus aztecus* Ives. Gudger (1916) says that the gafftopsail is an omnivorous feeder, but that the blue crab is its staple food.

Summary: The gafftopsail catfish is practically absent from shallow coastal waters in the winter. There is an influx of adults into the bays in spring. Breeding takes place there at about early May and the eggs and young are carried orally by the males until July when they are liberated. The young grow rapidly in the bays and begin to leave in the fall. In November they are found only in the Gulf and in December they disappear. A small number of observations tend to corroborate previous conclusions of Gudger (1916) that the blue crab is a staple food of this catfish.

Galeichthys felis (Linnaeus). Hardhead or Sea Cat

This fish is smaller than *Bagre marina* and is not ordinarily used for food. It was used for food during World War I and again in 1943. It is very abundant in shallow bay waters during the summer and much to the disgust of tourist fishermen, many of whom are unskilled in choosing the best time and place to fish, it is the species most commonly caught during the warm months. It greatly outnumbered the gafftopsail in all catches. It also outnumbered the gafftopsail in trawl catches in Louisiana (Gunter, 1936, 1938a). This catfish may be said to be more numerous than the gafftopsail in western Gulf waters. Smith (1907) reported the same situation at Beaufort, N.C., but Gudger (1916) disagreed with him.

Three thousand two hundred and seventy-five fish were caught, 1,038 in Copano Bay, 1,493 in Aransas Bay and 744 in the Gulf of Mexico. The average catch for all hauls in these three bodies of water was 6.7, 8.2 and 9.4, respectively. Thirty-seven fish were caught in minnow seines, 279 in large nets and 2,959 in trawls. The average catch for each kind of gear was 0.2, 2.4 and 27.1, respectively.

Table 4 shows that few fish were taken below a salinity of 5.0 per thousand, and it seemed to be most numerous in the saltier water above 30.0 per thousand. The fish were taken in water ranging from 2.0 to 36.7 parts per thousand salt.

There was a relation between the size of catfish caught and the salinity of the water. Below a salinity of 10.0 there were 68 fish from 58 to 68 mm. long, among a total of 322 fish. Above that salinity only 6 fish of the same size were taken among 1,638 specimens. Where the salinity of the water was 30.0 or above no fish less than 86 mm. in length were taken among 321 specimens, while below that salinity 120 fish out of 1,317 specimens were less than 86 mm. long. Fish above 300 mm. in length were caught over the whole salinity range.

The males of *Galeichthys felis* carry the eggs and young in their mouths. Goode (1903), revised by Gill, mentioned observations of Silas Stearns to the effect that this catfish carries its eggs in the mouth. Later Jordan (1905), stated that in many or all sea catfishes, among them being *Galeichthys*, the male carries the eggs in its mouth. Smith (1907) again mentioned the fact of oral gestation for this catfish. Lee (1937) has gathered the most extensive data concerning the breeding habits of this fish. She showed that during the breeding season females developed a triangular flap of the pelvic fins, which probably is concerned in some unknown way with spawning. Females with pelvics beginning to enlarge were first seen on March 18, 1942 in Aransas Bay long before the actual spawning time and were noted from then to July 12, in both bays. The enlargement did not disappear entirely until well after the breeding season and it was noticed in three females as late as October 22 in 1943. This was probably some four months after spawning. The size range of 140 females with the pelvic fin enlargement was 190 to 375 mm. in total length. The smallest fish observed by Lee (1937), which had the pelvic fin enlargement was 126 mm. in standard length.

On June 9, 1941, 1 spent and 3 ripe females were taken. On June 17, 1941, 11 females out of 14 caught were spent. On June 10, 1942, 5 out of 6 females were spent. On June 17, 1942, 3 out of 4 females were spent. On June 19, 1942, 2 ripe and 3 spent females were taken. On June 24, 1942, 3 spent and 5 ripe females were taken.

Table 18 gives the data on eggs and young taken from the mouths of the males. Loose eggs and young were sometimes found in the trawl hauls or in the boat after the taking of specimens, where evidently the parent fish lost them during the excitement of capture. The larger numbers given for eggs and young contained in the mouths of males are therefore more nearly normal than the lower figures. Lee (1937) found one fish that contained 48 eggs.

The earliest date that eggs were found in a male's mouth was June 10, ten days earlier than Lee (1937) found in Louisiana, and the latest date that eggs in early developmental stages were found was July 11. From the data given in table 18

and that on spent females, it appears that the breeding season begins in early June and lasts into early July. Possibly females spawn more than once in a season. A female taken June 9, 1941 had ovarian eggs in 3 stages, 2 yellow in color and the smallest white. The diameters were 13 mm., 6 mm., and 3.5 to 4 mm. One male was carrying one egg in quite an earlier stage than the other 24 he was carrying. Lee (1937) noted a similar instance.

The largest fish carried by the parent was 55 mm. long and they were liberated at about this size. Above 50 mm. in length the baby fish had used up all the yolk and only a slit or line remained in the belly to show where the yolk had been enclosed. The peak of liberation apparently comes in the first half of August, when the free swimming young were first noticed, after they have been carried by the male for approximately two months.

Most breeding catfish were noted in the lower bay, but spawning may have been scattered over the whole bay.

Very few fish were taken in winter. In January fish were caught only in the Gulf. In the spring fish returned to the bays and were caught there in large numbers. They were less numerous in summer and very few fish were taken in the Gulf in midsummer. Probably most of the fish were in the bays. Larger fish were most prevalent in the catches in June and July. Young fish, newly liberated, appeared in both 1941 and 1942 in August. Apparently they grew rapidly until October, but remained at about the same size, 93 mm. long, during the winter. Large numbers of catfish were found in the bays in the fall and this group was composed largely of young. Table 17 gives the numbers caught each month. It has been found that the abundance peak for this fish in trawl catches in Louisiana fell in September and October (Gunter, 1938c). When the temperature dropped in the fall the fish began to leave the bays and the population of the shallow Gulf rose sharply in November. In December very few fish were found in Copano Bay, but they were still present in some numbers in Aransas Bay. This covers the general movements of the species as well as it can be worked out from the data at hand.

Large fish, from 240 to 380 mm. long, were numerous only in June and July. The largest catfish caught was 423 mm. long. Size groupings of only the smaller fish could be followed clearly in length-frequency curves. In May, 1941 a group of fish from 113 to 123 mm. long was observed with a mode at 118 mm. The same group was still apparent, although less distinct in the curves, at lengths of from 133 to 158 mm. in October, 1941. In August, 1941 a small size group from 45 to 55 mm. long came into the catch. These small fish probably were not normally liberated by the males but had been dislodged during capture of the parent fish. The fish seemed to be about 55 mm. long at liberation. A second small group from 60 to 93 mm. long came into the catch at the same time. It was composed of free-swimming, recently liberated fish. This group grew rapidly and could be followed, except for almost complete absence in May and June, until August, 1942, when it was from 118 to 138 mm. long, with a mode at 128 mm. During the previous August, a similar size group had been from 128 to 148 mm. long. During August,

1942 the smallest group at from 48 to 68 mm. long, with some fish not normally liberated, came into the catch again.

In March, April, May and June, 1942, nineteen fish were noted with a red nematode parasite in a blister-like swelling under the skin of the caudal region. These worms were seen on no other part of the body.

The stomach contents of 85 hardhead catfish were examined. The fish were all caught in nets and ranged in size from 240 to 360 mm. in length, except for one fish 100 mm. long. Five fish contained indistinguishable material and 21 were empty. Twenty-three catfish contained only blue crabs and 24 fish contained only mud shrimp, *Calianassa jamaicense louisianensis* Schmitt. The remaining 11 fish contained blue crabs twice, *Calianassa* twice, peneid shrimp (*Penaeus aztecus*) twice, oyster crabs (*Panopeus*) twice, identifiable fish bones twice, mullet once, hermit crabs once, clam shells once, one nudibranch and one small *G. felis*. The blue crab and the mud shrimp, *Calianassa jamaicense louisianensis*, together make up about 90 per cent of the food of this catfish. The mud shrimp is rare to human collectors, but evidently catfish know how to find it in the bottom of the bay. Huge claws of soft shell crabs were sometimes found in catfish and apparently the soft crabs are rooted out from hideaways in the mud. This catfish practices cannibalism. The small catfish taken from a large one's stomach was eaten in October, long after the time when males were carrying on oral gestation, so the swallowing was not an accidental result of that activity.

Summary: This fish carries on oral gestation. Breeding is in June and early July in the bays. Young fish are liberated in August. The fish go to the Gulf in the fall and are largely absent from the bays in winter. They return in the spring. The blue crab and the mud shrimp, *Calianassa jamaicense louisianensis*, form the chief food of this catfish. This catfish was present in a wide range of salinities, but was most numerous in saltier water and less numerous in water below a salinity of 5 parts per thousand. There was a relation between the size of specimens and the salinity of the water in that the smallest fish were taken in the freshest water and fish below a certain size were never taken in the saltiest water.

Ameiuridae. Channel Cats

Ictalurus furcatus (Cuvier and Valenciennes). Blue Channel Cat

On July 28, 1941, one fish was caught near Mission Pass, Copano Bay. On September 29, 1941, three more were caught at Black Point, Copano Bay, near the mouth of the Aransas River. Both catches were with trammel nets. The temperatures at the 2 hauls were 29.8° and 27.1° C. and the salinities were 3.1 and 6.9 parts per thousand, respectively. The fish ranged in size from 28.0 to 30.5 cm. in total length. The stomach of the first fish contained indistinguishable material and algae, while the last three had been eating grass shrimp, *Palaemonetes*. This fresh water species evidently ventures into the bay when salinities are low.

In a letter dated June 1, 1942, Dr. Paul Bartsch, of the U. S. National Museum, gives the following information. Mr. John T. Lucker, of the Bureau of Animal Industry, Department of Agriculture, identified nematodes removed from the stomachs of the mud shrimp, *Calianassa jamaicense louisianensis* Schmitt, which the writer

had removed from the stomachs of the hardhead catfish, *Galeichthys felis*, and sent to Dr. Waldo L. Schmitt. They were larvae belonging to the super-family *Spiruoidea* and Mr. Lucker considered them to be identical with *Agamonema vomitor* Chandler, 1935, which was described from the stomach of the blue channel catfish, *Ictalurus furcatus*. As shown here, *I. furcatus* sometimes comes into the bay when salinities are low and during that time it may feed on *Calianassa*.

Ameriurus melas catalus (Girard). Black Mudcat

One specimen was taken in a minnow seine at Black Point, Copano Bay, February 17, 1942. The temperature was 15.5° C. and the salinity was 2.3. The fish was 108 mm. long. This fresh water catfish also ventures into the bay when the water is fresh.

INIOMI. Lizardfishes and Lanternfishes

Synodontidae. Lizardfishes

Synodus foetens (Linnaeus). Lizardfish

Although there may be other species of *Synodus* in this region, especially in the open Gulf, all specimens seen agreed with this species. Dr. Samuel F. Hildebrand corroborated the identification of several specimens.

Thirty-four lizardfish were taken in all, 1 in Copano Bay, 25 in Aransas Bay and 8 in the Gulf of Mexico. Six fish were taken in minnow seine hauls and the remainder in trawls. The single Copano Bay specimen was taken in November, 1941. Lizardfish were taken in Aransas Bay in October and November, 1941, and March, April, May, June and August, 1942. In the Gulf of Mexico lizardfish were caught from July to October, 1941, and at no other time. The number of fish caught each month varied from 1 to 12. Eighteen fish were taken in the months of October and November, 1941. No fish were taken in the winter.

The temperature where lizardfish were caught ranged from 14.4° to 30.5° C. The salinity range was from 13.7 to 36.7. Table 4 gives the data. Three small fish ranging from 37 to 41 mm. in length were taken in lower Aransas Bay in April, and another 45 mm. long was taken in May. In June and July two fish 61 to 73 mm. long were taken. During the remainder of the year fish were of larger size. The largest fish taken was 286 mm. long. Spawning probably occurs some time in the spring.

CYPRINODONTES. Killifishes and Top Minnows

Members of this group were found exclusively on the shallow marginal flats of the bays, very close to shore, among the grass, algae or oyster shells, with one exception, when a member of this group was taken in deep water, following a hard cold spell. These fishes likewise were not taken on the Gulf beach, with one exception. This is probably due to the lack on the Gulf beach of what game biologists have called "cover," for most of these fishes can live in waters of very high salinities. It may be said that members of this group are characteristic of and often are the predominant animals of shallow bay waters.

Cyprinodontidae. Killifishes

Lucania parva venusta (Girard). Southern Rainwater Fish

Four hundred and seventy-six specimens of this little fish were caught, 403 in Copano Bay, 46 in Aransas Bay and 27 in Salt Creek, a tributary of St. Charles Bay, which in turn empties into Aransas Bay. All fish were taken in minnow seines. The smallest fish caught was 16 mm. long and the largest was 53 mm. long. The fish was taken throughout the year at all variations of temperature from 8.8° to 33.0° C. This species is not as abundant as some of the other killifishes. None were taken on the island shore of Aransas Bay. Allen (1942) took the species only once during his study of feeding grounds of the Roseate Spoonbill in Texas.

This fish was not found in water of higher salinity than 24.2. The lowest salinity where the fish was caught was 2.1. Breder (1929) says the Atlantic Coast species is typically found in undiluted sea water. Table 4 shows that the fish was most abundant at salinities from 10.0 to 15.0. No correlation between size of specimens and the various salinities was found. According to Hildebrand and Schroeder (1928) the Atlantic species was common in all brackish waters of Chesapeake Bay, but was not taken in strictly fresh water.

Total length-frequency curves plotted by months gave little information. There seemed to be an increase in the relative numbers of larger individuals from July to October, with a subsequent falling off in numbers of this group, but specimens 43 mm. in length were present in January. The modes were sharp at 23 mm. in July and September, 1941. In January and February, 1942 they were sharp at 28 mm. In October and December, 1941 and March, 1942 the mode was broader, ranging from 23 to 28; in June and November, 1941 it ranged from 23 to 33 mm. The curves are not presented. Hildebrand and Schroeder (*op. cit.*) found in Chesapeake Bay that ripe females were taken from April to July and they state that it is probable the female spawns more than once a season. The presence of small fish at nearly all seasons of the year in Texas indicates a long breeding season.

Table 19 shows that this fish was most abundant in midwinter and least abundant in the spring. None at all were taken in April, 1942.

Fundulus grandis Baird and Girard. Gulf Killifish or Chub

This fish was caught only in the shallow waters of Copano and Aransas bays in minnow seines. Four hundred and fifty-four specimens were taken. One hundred and ninety-six fish were taken in Copano Bay and 258 were taken in Aransas Bay. They ranged in size from 19 to 141 mm. in total length. This killifish is quite active and many avoided the seines.

Specimens were taken at temperatures ranging from 13.0° to 34.0° C. and at salinities ranging from 2.0 to 37.1 parts per thousand. Table 4 shows that this fish became much less common at salinities above 25 parts per thousand. Hildebrand and Schroeder (1928) said they rarely took the closely related *F. heteroclitus* in strictly salt water. Only large fish were taken at the highest salinities, but there was no general correlation between size of specimens and the salinity where they were caught.

Ripe males and females were taken from March to June in 1942. Eight ripe males ranged from 89 to 134 mm. long, and 7 ripe females were from 70 to 129 mm. long. Fifty-seven males differentiated by color, ranged in size from 51 to 138 mm. in total length, while 61 females ranged in size from 36 to 141 mm. in total length. Hildebrand and Schroeder (1928) say that sexual maturity in the female of *F. heteroclitus* is attained at about a length of 1½ inches (38 mm.).

Fish above 113 mm. long were present irregularly but in most months. Fish from 23 to 28 mm. long came into the catch in June and July, 1941 and June and August, 1942. They were also present in December, 1941 and January, 1942. Fish of intermediate sizes were also present in most months. Either there was a second undetected season of breeding late in the fall, which seems improbable, or the young were confused with some other species. On the other hand, the rate of growth of this fish is unknown and the small fish appearing in December may have been spawned the previous summer. It should be stated, however, that the writer felt dissatisfied with the identification of small fish taken in winter.

Table 20 shows the distribution of catch in the two bays by months. The fish was caught in greatest abundance in summer and again in midwinter.

Fundulus similis (Baird and Girard). Black Chub

One thousand three hundred and sixty-two specimens were taken, all in minnow seines. Three fish were taken on the Gulf beach, 1,094 in Aransas Bay and 265 in Copano Bay. This species was taken at all seasons of the year at water temperatures ranging from 8.8° to 34.9° C. and salinities ranging from 2.0 to 37.1 parts per thousand. The size range was from 19 mm. to 139 mm. in total length. Like the other cyprinodontids *F. similis* is an inhabitant of the shallows and flats and was never caught in the open bay.

Table 4 shows that the fish was most abundant where the salinities ranged from 20.0 to 30.0 per thousand, and was less abundant but more or less equally distributed at other salinities, from the lowest to the highest. There was little relation between size distribution and salinities, but only the largest specimens were taken in the saltiest water. None greater than 103 mm. long were taken at salinities above 15.0.

This fish was the only cyprinodontid taken on the Gulf beach. Three were taken within fifty yards of the jetties on Mustang Island, near the mouth of the pass, in February, March and November, 1942. The salinity at the stations ranged from 27.9 to 32.6. The related fish, *Fundulus majalis* (Walbaum), was found on the outside beach at Beaufort, North Carolina by Pearse, Humm and Wharton (1942). *F. similis* was often taken at equivalent or higher salinities in the bay and high salinity is apparently not the reason why this fish and other cyprinodontids are not taken on the Gulf beach. Food is not lacking there and the writer postulates lack of cover as the probable reason for the absence of these little fishes on Gulf shores. On the other hand, Myers (1938) has pointed out that the Challenger once took a Fundulus in the mid-Atlantic. Only 20 specimens were greater than 100 mm. in length. For the whole catch the total length-frequency mode was at 33 to 38 mm. and above a length of 73 mm. the numbers declined progressively.

Table 21 shows that this fish, like *F. grandis*, was found to be most abundant in the summer and again in the winter, and least abundant in the spring and fall. Small fish from 23 to 43 mm. long came into the catch in abundance in July, 1941 and a few were present in June. Apparently they grew to about a length of from 43 to 73 mm. by November. Small fish again appeared in December and January, similar to *F. grandis*, and again in May and June. These results are so peculiar that again we have to take into consideration the possible confusion of the young with other species. There were usually two distinct size groups present, although in some months there was an overlap. In June, 1942 the small group of fish was from 20 to 52 mm. long with a mode at 33 mm. The second group was from 64 to 96 mm. long, with a frequency mode at 70 to 78 mm. The second group was thought to be approximately a year old.

Ripe males and females were taken from April 20, to August 26, 1942. Three males ranged in size from 61 to 69 mm. long and 17 ripe females ranged from 66 to 101 mm. long. Twenty-seven males, differentiated by color, ranged in length from 51 to 94 mm. long, while 25 females ranged from 50 to 110 mm. in length. Hildebrand and Schroeder (1928) noted that the females of *F. majalis* were larger than the males.

It was noticed that this little fish was adept at flipping across the ground and back into the water with unerring aim when they were dragged ashore in the seines. For that reason the minnow seine hauls often ended in a mad scramble to gather in the *F. similis* before they returned to the water. Hildebrand and Schroeder (1928) noted the same behavior in *F. majalis* and called attention to the previous work of Prof. S. O. Mast (Journal of Animal Behavior, 5 (5): 341–350) on the same subject.

Adinia multifasciata Girard. Banded Killifish

Forty-four examples of this little cyprinodont were caught, seven in Copano Bay and 37 in Aransas Bay. All fish were caught in minnow seines. The temperature and salinity range at stations were 12.2° to 28.5° C. and 8.4 and 35.7 parts per thousand, respectively.

The size range of specimens was from 20 to 35 mm. in total length and the total length-frequency mode was at 28 mm. The smallest fish was taken in December in Copano Bay. The largest was taken in Aransas Bay in February. Not enough specimens were taken for information on the life history.

Table 4 shows that fish were taken most often at medium salinities and were scarce at the highest salinities and absent at the lowest salinities. Specimens were taken in Copano Bay in the months of November and December, 1941 and March and April, 1942. In Aransas Bay the fish was taken in September and December, 1941 and January, February, March and June, 1942. This little fish was taken at all seasons of the year, but it was most abundant during the winter. Thirty-five specimens were taken in December, January and February and the other 9 caught were taken in other months.

Cyprinodon variegatus variegatus Lacépède. Sheepshead Minnow

This is the most prolific cyprinodontid on the Texas Coast. There were 6,673 specimens caught, 3,005 in Copano Bay and 3,668 in Aransas Bay. All were caught in minnow seines except one caught in a trawl. Allen (1942) has previously observed the great abundance of this little fish on the Texas Coast. The temperature and salinity ranges where the species was caught were 8.8° to 34.9° C. and 2.0 to 35.7 per thousand, respectively. No fish was caught in the Gulf of Mexico.

There was no relation between the size of specimens and the salinity where they were caught. Apparently the fish spawn and the young range all over the bays. Table 4 shows that *C. v. variegatus* was caught most often at salinities between 10.0 and 25.0 parts per thousand, and was less common above that range than it was below it. It is interesting to note, however, that on February 19, 1941 the writer took hundreds of *C. v. variegatus* at the upper end of Baffin Bay where the salinity was 71.5 parts per thousand. This peculiar environment will be treated in a later paper.

Hildebrand (1919) has shown that spawning takes place throughout the spring and summer. No data on the sexual condition of the fish was taken in the course of this study. The smallest fish caught was 12 mm. long and the largest was 93 mm. long. In this work only three specimens greater than 55 mm. in length were taken. One was 58 mm. long, another was 88 mm. long and the last was 93 mm. long. The last two are the largest that have ever been recorded (see Hildebrand and Schroeder, 1928). In June, July and August, 1941 fish from 28 to 53 mm. long were present with a mode at 43 mm. Between August and September this group disappeared and was not re-established until June, 1942. Between June and August, 1942 it disappeared again. This seems to indicate a rather short life cycle. Small fish with a mode at 18 mm. were present in greatest numbers in July, 1941, but some were still present in December. From that time on a general slow growth of the population took place until June, when the fish had attained a mode at 43 mm. and the small group with a mode at 18 mm. also reappeared. The larger fish largely disappeared again between June and August. Allen (1942) noted very tiny examples of *C. v. variegatus* in May in San Antonio Bay. In short, spawning covers a long period and the young, around 18 mm. long, feed into the population from June until December. From then on growth takes place within a closed population and the largest animals disappear in summer, probably after spawning.

Table 22 shows that the greatest abundance of this species was during the winter months, from December to February, as would be expected if the young of the year were feeding into the population throughout the summer and fall, bringing it to a peak. The absence of fish in April and the almost complete absence in May is unexplained. The almost complete absence of the fish in October is probably due to the fact that the species migrated to warmer and slightly deeper water at the first drop in temperatures in the fall. This disappearance is correlated with movements of other fishes, some of them into the Gulf at the same time, and apparently for the same reason. However, *C. v. variegatus* did not go into the Gulf,

and possibly the fish merely moved offshore until they became accustomed to the lowered temperatures. There is another indication that this fish migrates to deeper water when temperatures are falling. It was the only cyprinodontid taken in trawls. One specimen was taken in a trawl in Lydia Ann Channel during a cold spell in January, 1942. It has been indicated before (Gunter, 1935) that certain shore fishes in the bays migrate to deeper water during cold spells, where they may be caught by trawls.

Poeciliidae. Top Minnows

Mollienisia latipinna LeSueur. Common Sailfin

Only one specimen was taken during this study. A female was caught December 19, 1941, near the mouth of the Aransas River in a minnow seine. It was 51 mm. long. The temperature was 19.5° C. and salinity was 10.0.

This fish seems to be locally common in sheltered places, with large areas in between where none exist. I found it abundant in drainage ditches of the field at High Island, Texas in 1941. It was also found common in the cove known as Little Bay in Aransas Bay in 1942, but no data were recorded. Possibly the species was not caught more often during this work because stations were on the shores of the open bay and not in sheltered places. Hubbs (1933) says this species breaks up into local subspecies and races. The spotty distribution of the species is conducive to such local differentiation.

This species apparently lives naturally at all salinities. Hubbs *(op. cit.)* speaks of races in fresh water in Florida and Louisiana and the salt water races of Key West. Herre (1929) has shown that in the Philippines where it has been transplanted, *M. latipinna* is abundant in ponds with a salinity of 87 parts per thousand salt. This as far above the salinity of sea water.

SYNENTOGNATHI. Needlefishes, Halfbeaks and Flying Fishes

Belonidae. Needlefishes and Houndfishes

Strongylura marina (Walbaum). Needlegar

Twenty-two needlegars were caught in the minnow seines, 6 in Copano Bay, 11 in Aransas Bay and 5 on the Gulf beach. This fish was taken more or less in equal numbers at salinities from 3.0 to 36.9. It is known to enter rivers and is euryhalin (Gunter, 1942a).

The fish was not caught during the winter. The temperature range at stations where it was caught was high, being from 27.0° to 33.2° C. The needlegar was caught in June and September, 1941 and June and August, 1942, in Copano Bay. It was caught in June, September, October and November, 1941 and during May, June and August, 1942 in Aransas Bay. It was taken in June, 1941 and August, 1942 on the Gulf beach.

Needlegars are more common than the catches indicate. They are commonly seen by lantern light on sand flats at night, where they apparently come in to feed. Some specimens range up to a foot or more in length. The fish caught by the writer were from 53 to 273 mm. long.

Hemiramphidae. Halfbeaks

Hyporhamphus unifasciatus (Ranzani). Common Halfbeak

One fish was caught in a minnow seine at Frandolig's Point, Aransas Bay, Minnow Seine Station 5, on August 26, 1941. It was 95 mm. long. The temperature was 33.0° C. and the salinity was 13.2. Three fish were caught in a minnow seine on the Gulf beach of Mustang Island, 5 miles south of the jetties, on August 31, 1941. The water temperature was 30.5° C. and the salinity was 36.6 parts per thousand. The lengths of these three fish were 41, 52, and 163 mm.

ANACANTHINI. Grenadiers, Cods and Hakes

Gadidae. Codfishes

Urophycis floridanus (Bean and Dresel). Gulf Hake

Fifty specimens of this little hake were caught, 1 in Copano Bay, 34 in Aransas Bay and 15 in the Gulf. They were all caught in trawls. The size range was from 73 to 203 mm. in length.

The salinity range where the fish were caught was from 13.3 to 34.2 parts per thousand. Only 1 fish was caught below 17.7 and table 4 shows that over half the fish were caught where the salinity was above 30.0.

Table 23 shows that the fish was caught from February to May. This fish is a denizen of offshore deeper waters in the summer and is not present in bays and shallow Gulf except in the winter and spring. This was shown before in Louisiana waters (Gunter, 1938c) where the fish was taken from December to May. In Louisiana the fish was caught in greatest numbers in February. In Texas the greatest abundance was in March. Jordan and Evermann (1898) previously noted the winter appearance of this fish at Pensacola. Hildebrand and Schroeder (1928) recorded similar information on *Urophycis chuss* (Walbaum) and *Urophycis regius* (Walbaum) in Chesapeake Bay.

The temperature range where fish were caught was from 11.1° to 24.0° C. It is interesting to note that although the fish remained until the temperatures became quite warm in the spring, they did not appear in the winter until the temperatures had become quite low. This was also previously noted in Louisiana (Gunter, *op. cit.*). The winter of 1931–32 was quite mild there and this fish did not appear until after a sharp freeze in March. In Texas the species did not appear until after the freeze in January, 1942. It may be said that this hake enters shallow waters when the temperatures are at their lowest in the winter and there is some indication that this influx follows sharp drops in temperature.

ACANTHOPTERYGII. Spiny-rayed fishes

Lophobranchii. Pipefishes and Seahorses

Syngnathidae. Pipefishes and Seahorses

The pipefishes are very difficult to identify. Even the foremost students of this group cannot distinguish the females of some species. Dr. S. F. Hildebrand and

Dr. E. S. Herald have identified specimens for me, but field identifications are, of course, my own. Except for the adults of *Syngnathus scovelli*, which are easily distinguished by the silvery markings on the sides, the identifications are provisional. These fishes are probably much more common on grassy shores of the bays than the catches indicate for they easily pass through fine mesh nets. They were not caught on the Gulf beach probably because of the barren shore and lack of cover.

Syngnathus louisianae (Günther). Louisiana Pipefish

Four specimens were taken, all in Aransas Bay, 2 in November, 1 in December and 1 in August. The salinity ranged from 13.3 to 35.0 parts per thousand and the temperatures were from 17.8° to 30.3° C. Two fish were caught in the upper bay and 2 were caught in Lydia Ann Channel. The lengths of the fish were 98, 147, 226 and 255 mm. The two largest specimens were from Lydia Ann Channel.

Syngnathus mackayi (Swain and Meek)

Two specimens were caught at Redfish Point, Copano Bay and two were taken in the upper end of Aransas Bay in minnow seines. The size range of specimens was from 70 to 98 mm. The temperatures were 19.0° to 24.9° C. and the salinity range was from 12.3 to 18.6. The pipefish were caught in November and December, 1941, and March, 1942.

Syngnathus scovelli (Evermann and Kendall). Southern Pipefish

This is the commonest pipefish on the Texas Coast. Ninety specimens were taken in Copano Bay and 60 in Aransas Bay at all seasons. All were caught in minnow seines. The salinity range was 3.2 to 26.3 and the temperature range was from 13.0 to 31.0° C. Since many small fish were probably included among the unidentified group (see below), a study of the total length data on this species was not made. The largest specimen caught was 150 mm. long.

Males ranging from 80 to 96 mm. in length and carrying eggs were taken in the months of June, August, and November. Males with young in the pouch were taken in October.

Syngnathus spp.

Eighty-six unidentified pipefishes were taken from both bays. They were probably chiefly young and immature specimens of the above 3 species.

Hippocampus regulus Ginsburg. Seahorse

One seahorse, 74 mm. long, was taken in a trawl 2 miles offshore from Aransas Pass in the Gulf of Mexico on May 25, 1942. The water temperature was 23.5° C. and the salinity was 26.7. The depth of the water was about 35 feet. The animals appear to be uncommon.

PERCOMORPHII

Atherinidae. Silversides

Menidia beryllina peninsulae (Goode and Bean). Gulf Silverside

Ten thousand and fifty-four specimens were caught, 2,753 in Copano Bay, 7,253 in Aransas Bay and 48 in the Gulf of Mexico. The fish were taken every month. Only 7 fish were taken in trawls. Six of these were taken in Lydia Ann Channel immediately after a cold spell in January, 1941, and 1 was taken a month later at the same place when the water temperature was still low. It has been shown before (Gunter, 1935) that this fish is rare in trawl catches. It inhabits the shallows of the bays and is very often the dominant species in that area, so far as numbers are concerned. Allen (1942) says that in the shallows where spoonbills feed, aside from killifishes, the silversides were met with most consistently.

An average of not less than 33.2 fish and not more than 95.1 per haul were taken in water at the various salinities. Table 4 shows the numbers caught. It may be said that this species was more or less equally distributed at all salinities. On February 19, 1941, *M. b. peninsulae* was taken at Caroline Beach, Baffin Bay, where the salinity was 71.3 parts per thousand. On May 9, 1941, after heavy rains in this region the salinity had dropped to 2.2 and the fish were still present. In the Copano-Aransas area fish were taken at salinities ranging from 0.0 to 34.9.

There appeared to be some relation between the size of fish and the salinity where they were caught, as is shown by figure 6. Above a salinity of 25.0 parts per thousand the fish were slightly larger than they were below that salinity.

Fish with developing and ripe gonads were taken from February 17 to August 18, 1942. Fifty ripe and developing males averaged 50.9 mm. in length and 168 ripe and developing females averaged 59.5 mm. in length. Hildebrand and Schroeder (1928) found that the females of *M. b. beryllina* in Chesapeake Bay were larger than the males. It appears that there are two spawning peaks or beats in a season, one in the spring and the other in late summer. Hildebrand and Schroeder said that *M. b. beryllina* in Chesapeake Bay probably spawned twice in a season. Figure 7 shows that young fish appeared in large numbers in April in 1942. In 1941 signs of the April group were present in June, but another small group of fish came into the catch in September and October, chiefly in October. These small fish apparently had a length-frequency mode at between 33 and 38 mm. in December. In May it had increased gradually to 58 mm. Fish between the sizes of 68 and 88 mm. began to disappear in August, 1941, and by September they were gone. This size was not fully established until April, 1942, and in June and August it showed signs of disappearing again. A very short life cycle is indicated with the fish disappearing after spawning, probably during the second year of their life. The smallest fish caught was 16 mm. long and the largest was 91 mm. long.

Table 24 shows that this species was caught in greatest numbers in June, July and August following the time when the young came into the catch. The same thing caused the small peak noted in November, 1941.

A peculiar observation concerning this fish was made. The gonadal condition was examined by pressing the fish between the thumb and forefinger and causing the gonads to extrude. Under this treatment when the gonads did not come out it was noted several times that the whole anal fin became suddenly suffused with a white silvery color, apparently from material forced out from the abdomen by pressure. This material remained in the fins when the pressure was released.

Membras vagrans vagrans (Goode and Bean). Rough Silverside

Seven hundred and ten specimens were taken, 287 in Copano Bay, 196 in Aransas Bay and 227 on the Gulf Beach. Like the preceding species, this fish is an inhabitant of the shallows and flats and none was caught in the trawls.

The salinity range where specimens were taken was from 2.5 to 36.6. Table 4 shows peculiarly that this fish was most abundant in the freshest water and in water of high salinity with fewer fish caught at salinity ranges in between. This distribution was largely due to the fact that the fish came into Copano Bay in large numbers in August in both years when the salinity was quite low, and were also taken in numbers on the Gulf beach in November where the salinity was high. Although many small fish were taken in saltier water, where probably they were spawned, the largest fish were only found in the saltier water.

Ripe males and females from 63 to 85 mm. long were taken in March and April, 1942. In June, 1941 length-frequency curves showed a small size group from 28 to 48 mm. in length. In July the fish were from 18 to 53 mm. long. There was evidence of bimodality at 33 and 43 mm. in June and at 33 and 48 mm. in July. In August this group was from 23 to 68 mm. long and in September it was from 38 to 63 mm. long with a distinct mode at 53 mm. in both months. In October more young fish came into the catch. The range was from 18 to 63 mm. with a distinct mode at 33 mm. In November the fish were from 23 to 58 mm. long with a sharp mode at 38 mm. There was a larger group also present in smaller numbers. In June these fish were from 68 to 98 mm. long and in July they were much more numerous with a mode at 83 and 88 mm. After that they disappeared although stragglers of 73 and 78 mm. long were taken in August, September and November. After November all fish disappeared.

In March and April, 1942 fish from 58 to 93 mm. were taken. In May small fish from 23 to 38 mm. appeared with a mode at 28 to 33 mm. This group grew rapidly and in August it was from 33 to 58 mm. long with a mode at 53 mm. A few stragglers of the larger group were taken throughout the summer and in October the only fish caught measured from 68 to 88 mm. long.

Table 25 shows that this fish was not caught in December and January. Hildebrand and Schroeder (1928) reported that the species was not found during the winter in Chesapeake Bay. It was found here that the lowest temperature at which this fish was caught was 18.4° C. The highest temperature was 33.2° C. It was caught in greatest numbers in midsummer in the bays and during November on the Gulf beach. The increased numbers on the Gulf beach were apparently due to an exodus from the bays with the onset of lower temperatures in the fall.

Mugilidae. Mullets

Mugil cephalus Linnaeus. Striped Mullet

The mullet is one of the most numerous of all fishes in the area studied and it can be found on any flats and shallows at practically all times. The mullet is adept at jumping and most large fish surrounded by the trammel nets got away by jumping over the nets, while the smaller fish went through. Only a small fraction of them were caught. Special mullet nets are employed in taking this fish.

One hundred and six fish were caught in trawls, 372 in nets and 4,562 in minnow seines. The fish caught in nets were large, those caught in minnow seines were small and those taken in trawls were of medium size. The mullet is seldom taken in trawls in any numbers. Four hundred and twenty-three striped mullet were caught in Copano Bay, 4,061 were taken in Aransas Bay and 556 were caught on the Gulf beach.

Mullet in the bays began to show yellow roe and milt in October and continued to have well developed gonads through December. Fish in Aransas Bay had larger roe and milt than fish in Copano Bay. A few fish in January had large roe and milt, but most of them during that month had small roe and milt, tinged with a pink coloration, and it was surmised that they were spawned out. Males with milt and developing milt ranged from 200 to 355 mm. in length and females in comparable condition ranged from 250 to 350 mm. in length. Only 7 males out of 34 were over 300 mm. long, while 19 females out of 41 were above 300 mm. long.

During the fall "roe mullet" collect around the passes leading into the Gulf, and although this is not shown by the data, table 26 shows that large fish, those caught in nets, became scarce in the bays in September and especially so in October, 1941. Young first appeared in the minnow seine catches in December, 1941 on the Gulf beach and in lower Aransas Bay. In 1942 they were first taken on the Gulf beach in November. They were 24 to 25 mm. long. In January, 1941, they appeared in huge numbers and had by that time spread into Copano Bay. These small mullet continued in minnow seine catches in large numbers until March. They grew rapidly. A few were caught in April. Some of the small fish, especially in the later months, may have been *Mugil curema* for the young of the two species are difficult to separate in the field. In June, 1941 the largest of the young were 33 to 108 mm. long. In November, the small mullet, in all likelihood the same group, ranged from 103 to 148 mm. long. They were then about one year old.

In summary, the large mullet go to the Gulf in the fall and congregate near the passes on the outside beaches. Spawning takes place there and extends from late October to early January, with the peak probably falling in late November and early December. Young mullet first appear on the Gulf beach and the lower bay in November and December and soon spread all over the shallow areas of the bays. They were taken most abundantly in January. After spawning the large mullet scatter out again and large numbers of them return to the bays.

This rather simple picture of mullet spawning and movements of the old and young observed here is essentially the same as that reported in Florida by Captain

J. L. Sweat (Hildebrand and Schroeder, 1928). It also corresponds with observations of Higgins (1927) and scattered observations of other workers throughout the years. Schroeder (see Hildebrand and Schroeder, *op. cit.*) says mullet spawn in Florida in November and December. Hildebrand and Schroeder *(op. cit.)* said that the mullet did not spawn in Chesapeake Bay, but that spawning could not have been far away, for small fry came into the bay in April. Breder (1940) observed mullet spawning in inside waters in Florida in February. He did not mention the salinity, but in all probability it was quite high.

Large mullet ranged up to 423 mm. in length. They were caught scatteringly but were most often caught from October to January. Most of them ranged from 243 to 363 mm. in length.

The striped mullet is euryhalin and mullet have often been reported from fresh water (see Gunter, 1938b, 1942a). Except for the large numbers of small fish taken at medium salinities when they first entered the bay, the mullet was about equally distributed in waters of all salinities. This is shown in table 4.

Mugil curema Cuvier and Valenciennes. White Mullet

Six hundred and nineteen fish identified as white mullet were caught. Others may have been confused with the young of the striped mullet. Seventeen fish were caught in Copano Bay, 414 in Aransas Bay and 188 in the Gulf. One fish was caught in large nets, 26 in trawls and 593 in minnow seines.

Strange as it may seem, the taxonomic status of these two common fish, the striped and white mullet, is not clear, and it should be studied carefully in the future before further work on life histories is done. The very young of the white mullet are practically indistinguishable from those of the striped mullet. From around 45 mm. to 143 mm. in length the white mullet is very silvery in color, has golden pigment only at the upper part of the iris, has a bright golden spot on the operculum and has a bright blue spot at the base of the pectoral fin. Striped mullet of the same size are less white, the eye pigment is present over most of the eye and is browner and duller, there is no golden spot on the operculum and the pectoral spot is a duller blue. These characteristics correspond with the anal fin count of III, 8 and III, 9, ordinarily used to separate the striped and white mullet, respectively. The color of *M. curema* described here seems to be somewhat brighter than that described by Hildebrand and Schroeder (1928) for Chesapeake Bay specimens.

Only 1 white mullet above 143 mm. (about 5½ inches) was caught. This specimen was 303 mm. long. It was taken in a trammel net in Copano Bay in December, 1941. Where the large specimens go is a puzzle. Mr. Albert Collier told me that he previously observed the same situation. Hildebrand and Schroeder *(op. cit.)* found the same thing to hold true in Chesapeake Bay. The largest specimen in their collection was 148 mm. long. Jacot (1920) only took small fish during the summer and early fall in North Carolina.

Small fish from 23 to 38 mm. with a mode at 33 mm. appeared in May and June, 1942, with a straggler in July. The same size group was noted in June, 1941, with stragglers in July, August and October. Small fish did not continue

to feed into the catch after July and the size of fish caught increased rapidly during the summer. The fish practically disappeared from the catches by October in both years. Probably spawning is in the late winter and spring, but conclusions can not be drawn.

Table 27 shows that this mullet was practically absent from the bays between October and April, inclusive. The greatest abundance of the fish was found in June and July. Apparently, the small specimens of *Mugil curema* come into the bays in the late spring, and leave in the fall. This corresponds with the time when the temperature drops. No undoubted example, except for the large fish caught, was taken in the bays at a water temperature lower than 26.5° C. In October and November, 1942, after the fish had left the bays, six were taken in minnow seines on the Gulf beach, at water temperatures of 20.5° and 22.0° C.

In summary, it seems that fish of the zero year class, with a modal length around 33 mm. first come into bays about May, closely followed or accompanied by a larger group, probably fish of the one year class, with a modal length around 63 to 68 mm. After rapid growth during the summer the fish leave the bays at the time of the first temperature drop in the fall and leave the Gulf beach at about the same time or shortly afterwards. Only one adult was caught and the whereabouts of the adults remains puzzling. With the exception of the one adult taken, the fish taken in salt water were larger than those in fresher water. At salinities below 14.9 the size range of fish was from 28 to 98 mm. At salinities of 15.0 and above the size range of fish caught was from 25 to 138 mm. Table 4 shows that the white mullet was taken at all salinities, but was slightly more common at the higher salinities.

Sphyraenidae. Barracudas

Sphyraena guachancho Cuvier and Valenciennes. Small Barracuda

This small barracuda, known in the West Indies as the guachanche, was reported previously from Louisiana (Gunter, 1935). One specimen, 163 mm. long, was taken in a trawl 2 miles southeast of Aransas Pass in the Gulf of Mexico on August 30, 1941. The water temperature was 30.0° C. and the salinity was 36.7.

Polynemidae. Threadfin

Polydactylus octonemus (Girard). Threadfin

The threadfin has the eight ventral rays of the pectoral fin separated and growing out as long individual rays. The fish was observed to turn them forward and run along the bottom. This makes an effective scoop-net which funnels small organisms into the mouth. Small organisms going into the mouth were not observed, but it is a practical certainty that the fish feeds this way. Whether or not the fins are used in this manner when the fish is swimming through open water or only when moving along the bottom cannot be stated. Mr. J. L. Baughman has observed this fish and he thinks the elongated fin rays serve as tactile organs. He has caught large specimens on baited hooks.

Two thousand three hundred and thirty-seven threadfins were caught, 208 in Copano Bay, 677 in Aransas Bay and 1,452 in the Gulf of Mexico. Twenty-three fish were caught in large nets, 928 in minnow seines and 1,386 in trawls. Table 28 gives the monthly catch. It shows that the fish was present from April to October in bays, while a few were caught in the Gulf in November. It also shows that the threadfin was caught most often in midsummer. The temperature range where the fish was caught was from 18.4° to 32.0° C. In short, the threadfin appears in this region when the water warms up in the spring and leaves when the temperature drops in the fall. The time of appearance and disappearance of the threadfin in Texas waters was the same as was found in Louisiana (Gunter, 1938c). In Louisiana in trawl hauls it was found that one year the fish was most abundant in the Gulf of Mexico, while the following year it was most abundant in the bay (Gunter, 1936). The Texas data show that the average catch per trawl haul, during the months the fish was present, was 17.8 for the bays and 29.4 for the Gulf. The average was greatest for the Gulf hauls in both years. Table 28 shows that the fish was also much more abundant in minnow seine hauls in the Gulf.

The smallest fish caught was 23 mm. long and the largest was 204 mm. long. The smallest fish appeared in the Gulf and lower bay in the spring. Four fish from 83 to 153 mm. long were taken in April and May, 1941. Length-frequency curves showed a small group of fish appeared in June, 1941, which ranged in size from 23 to 43 mm. long with a mode at 33 mm. In July the range was from 33 to 53 mm. and the mode was at 43 to 48 mm. In August the range was from 53 to 83 mm. with the mode at 78 mm. During these months the curve overlapped with a larger group of fish, part of which had a mode at 78 mm. in June. This larger group ranged up to 153 mm. long that month. Thereafter no mode could be distinguished for the larger fish and in July the size range was from 58 to 183 mm. long. In August the size range of larger fish extended up to 203 mm. In September the smaller group could no longer be distinguished and there was no mode. The size range of all fish was from 78 to 213 mm. In October the size range of all fish was from 133 to 193 mm. with a broad mode at 163 to 168 mm. In November 4 fish from 153 to 168 mm. long were caught on the Gulf beach. Thereafter the threadfins disappeared.

In 1942 the picture was different. None of the smallest fish and few of the larger ones were caught. A scattered few of the largest size range, measuring 163 to 183 mm. long were taken in April, May, and August. All other fish belonged to one group which could be followed throughout the warm months. In April this group was from 63 to 103 mm. long with a definite mode at 83 mm. In October it was from 113 to 163 mm. long with a mode at 143 mm. In October one fish 133 mm. long was caught and thereafter no more threadfins were caught. Growth was evidently rapid during the summer and before they disappeared no fish under 113 mm. in length were present.

Table 4 shows the numbers of fish caught and the average catch at various salinities. The fish was most abundant at high salinities, but peculiarly it was more abundant at the lower salinities than in waters of intermediate salinities. The salinity range at which the threadfin was caught varied from 2.1 to 36.7 parts per

thousand. No relationship between salinity and size of the fish was noted, except that fish below 53 mm. long were all taken in the Gulf in waters of high salinity. Spawning apparently takes place in offshore waters probably in the late winter or early spring and later the fish approach the coast.

Cybiidae. Spanish Mackerels and Kingfishes

Scomberomorus maculatus (Mitchill). Spanish Mackerel

It is generally thought that the Spanish mackerel strikes the South Texas Coast in large schools near Port Isabel every spring and works up the coast to Galveston and beyond. However, Baughman (1941b) reported that in 1940 mackerel were first reported off Galveston on March 9, but they did not appear at Port Aransas, 200 miles farther south, until March 26.

The Spanish mackerel is the potential base for an extensive commercial fishery on the Texas Coast, but today it is caught only in small numbers and the total annual production is probably far less than one per cent of the available supply (Gunter, 1943b, 1943c). Statistics on the commercial catch (Ann. Report, Game, Fish and Oyster Comm. 1936–37 to 1941–42) show that the annual production for six years has fluctuated between 6,756 and 29,778 pounds with an average production of 18,372 pounds. Mackerel enter the bays in the summer, but mostly they are caught in the Gulf near the passes and 88.8 per cent of the catch is from the Gulf. The Annual Report of the Game, Fish and Oyster Commission for 1941–42 shows that the Aransas Pass region produced 18,781 pounds of the 18,932 pounds for the whole coast during the fiscal year.

Table 29 shows that in most years the Spanish mackerel is not caught on the Texas Coast from November to March, inclusive, but that the only month when it was not taken at all from 1936 to 1942 was February. The table also shows that it is caught in greatest numbers in August. Apparently the Spanish mackerel begins to leave the Texas Coast in September.

The gear used in this work was not suitable for catching Spanish mackerel and only 4 were caught. Two fish 43.5 and 45.5 cm. long were caught in a seine on the Gulf beach of Mustang Island, 1 mile south of Corpus Christi Pass on July 6, 1941. One fish 45.5 cm. long was caught in a trammel net on the Quarantine Shore of lower Aransas Bay, August 7, 1941. One specimen 219 mm. long was caught in a trawl in the Gulf 2 miles offshore from Aransas Pass on August 30, 1941. The temperature range at the stations was 28.0° to 30.0° C. and the salinity range was from 31.1 to 36.7 per thousand.

Trichiuridae. Cutlassfishes

Trichiurus lepturus Linnaeus. Ribbonfish or Cutlassfish

This fish is commonly caught on hook and line around docks and wharves. It will bite viciously after being landed. Over 2,800 specimens were caught in 2 years of trawling in Louisiana (Gunter, 1936, 1938a), but only 86 specimens were caught during this survey. All of them were taken in trawls. Apparently this species is less numerous in the Aransas Bay region of Texas than in the Barataria

Bay region of Louisiana. Nevertheless, the fish is common along the Texas Coast, as is stated by Baughman (1941b), but possibly the greatest concentration lies to the east of the Aransas Bay region.

One fish was caught in Copano Bay, 61 were caught in Aransas Bay and 24 in the Gulf. The Copano fish was taken in May, 1942. In Aransas Bay cutlass fish were caught in the months of July, September, November and December, 1941 and February, March and Arpil, 1942. The number of fish caught in a month varied from 1 to 22 and fish were taken in greatest numbers in July, November, March and April. No fish were caught in January, 1942. This is the only month that the fish was absent from the catches. The temperature range at which it was caught was from 14.2° to 30.1° C. The salinity range was 13.0 to 36.7 parts per thousand. Table 4 shows that the fish was taken rarely at below medium salinities. The smallest fish caught was 236 mm. long and the largest was 520 mm. long.

Four specimens were found with part of the tail cut off. It is easy to understand how this long ribbon-like fish can lose a large part of its tail to a predator. One fish was caught that had survived being cut in two just back of the anal region. The wound was perfectly healed. The fish measured only 250 mm. in length. What remained compared almost perfectly in size with a fish 480 mm. long taken in the same haul. Assuming that 480 mm. would have been the length of the whole fish, then it is seen that approximately 230 mm. or over 47 per cent of its normal length was missing.

Stromateidae. Harvestfishes

Peprilus paru (Linnaeus). Harvestfish

Six specimens were caught, all in trawls and all in the Gulf of Mexico, in August, 1941 and January and March, 1942. Two fish were caught in the January haul at the Whistling Buoy, 5¼ miles SSE of Aransas Pass. The other two hauls were made two miles from the pass. The temperature range at the hauls was 13.7° to 30.0° C. and the salinity range was 33.0 to 36.7. The size range of the fish was from 98 to 128 mm. Baughman (1941b) has stated that this fish does not reach sufficient size in Texas to be economically valuable as it is on the east coast of the United States.

Poronotus triacanthus (Peck). Butterfish

Forty-seven butterfish were caught, 15 in Aransas Bay and 32 in the Gulf. Two fish were caught in trammel nets. The remainder were taken in trawls. The fish was caught in all seasons. It was taken in August and December, 1941 and March, 1942 in Aransas Bay. In the Gulf it was taken in June and November, 1941 and in March, April and May in 1942. The temperature range where catches were made was from 12.6° to 28.0° C. The salinity ranged from 15.6 to 35.2 where this fish was caught. Table 4 shows that most fish were taken where the salinity was greater than 30.0. The size range of specimens was from 37 to 200 mm. The smallest specimens were caught in the Gulf in June. Only 2 fish, 170 and 200 mm. in length, were large enough for eating. They were taken August 7, 1941. The smaller fish had yellow roe. Apparently few fish reach large size in Texas waters

and the species, like *P. paru*, is never sold for food in Texas, as it is on the Atlantic Coast. This fish like *T. lepturus* was taken much less commonly in Texas than in Louisiana, see Gunter (1936, 1938a) for comparison with Texas data. In Louisiana it was found that this species was most abundant in March (Gunter, 1938c). The numbers are small, but 21 of the 47 fish caught in Texas were taken in March, 1942.

Carangidae. Jacks and Pompanos

Trachurus lathami Nichols. Rough Scad

Twenty-nine specimens, ranging in size from 99 to 120 mm. in length, were caught in a trawl 5 miles SSE of Aransas Pass in the Gulf of Mexico on July 7, 1941. The water temperature was 28.3° and the salinity was 35.8. The previous summer a few specimens were caught by fishermen in the same locality. Evidently the fish is common only sporadically during the summer. Baughman (1941b) reported one specimen from Galveston and cited the writer as stating that the fish was common about Rockport. However, there was some misunderstanding. I have never seen the fish in the bays, and it has been noted only sporadically in the Gulf as stated above.

Hemicaranx rhomboides Meek and Hildebrand

Six specimens of this fish ranging in size from 32 to 82 mm. were caught. All were caught in Aransas Bay, 1 in a trawl and 5 in minnow seines. They were taken in the months of June and July, 1941 and in August, 1942. The temperature at the stations varied from 30.5° to 32.0° C. and the salinity varied from 16.8 to 24.7 parts per thousand. The fish was first described by Meek and Hildebrand (1925) from Fox Bay, Colon, Panama. This is the first record of it from the United States. Dr. S. F. Hildebrand identified some of the specimens.

Caranx hippos (Linnaeus). Jackfish

This is a common carangid along the Texas Coast and the adults are commonly caught by sports fishermen at Port Aransas and other points along the coast. Large jacks are seldom caught except by hook and line. Thirty-four specimens were caught in the course of this work, ranging in size from 30 to 285 mm. in length. Two were taken in Copano Bay, 12 in Aransas Bay and 20 in the Gulf of Mexico. Three fish were taken in large nets, 10 in trawls and 21 in minnow seines. The lowest temperature where the jack was caught was 25.5° C. and the highest was 30.5° C.

The salinity range at stations was from 4.8 to 36.4. Table 4 shows that only two fish were taken below a salinity of 15 parts per thousand and the majority of specimens were taken in water with a salinity higher than 30.0.

In Louisiana (Gunter, 1938c) this jackfish was taken in trawls in Barataria Bay from July to November. In the Gulf they were taken as early as April and as late as November. This jack was taken in the bays in Texas only from August to October. In the Gulf it was found from June to October. The smallest fish taken first appeared on the Gulf beach in June. They were from 30 to 42 mm. long.

In August the size range was from 36 to 59 mm. in length. One fish taken on the Gulf beach was 146 mm. long. Baughman (1941b) has reported taking the young in June on the beach at Galveston and he described the color which is light brassy-green overlaid with vertical bars. The young jacks enter the bays later as they grow larger and the fish taken there ranged from 90 to 285 mm. in length. Apparently they come in at about midsummer for observations made in both Texas and Louisiana, covering 4 seasons agree on this point. Nevertheless, the largest fish generally remain in the Gulf and are seldom taken in the back bays. Hildebrand and Schroeder (1928) state that *Caranx hippos* usually appears in Chesapeake Bay in July and August. August was the month when the fish was found most numerous. Twenty-two out of the total 34 caught were taken in August 1941 and 1942.

Vomer setapinnis (Mitchill). Moonfish

Three hundred and six specimens of the moonfish were caught, all in trawls except for 3 taken in beach seines. Twelve fish were taken in Aransas Bay and 294 were taken in the Gulf of Mexico. In Louisiana (Gunter, 1938a) it was found that this fish was over twice as abundant in trawl catches in the Gulf as in the bay. The fish was also taken much more abundantly in Louisiana than in Texas.

The lowest temperature at which the fish was caught was 14.2° C. and the highest temperature was 30.0° C. Table 30 shows the monthly catches. The moonfish was taken every month except January and February. The time of greatest abundance was in August, with the least numbers caught in December and March just before its disappearance and after reappearance. In Louisiana (Gunter, 1938c) the time of greatest abundance was in September and October. Fish from 43 to 58 mm. long were taken from July to October, but at no other time.

One fish was taken in the middle of Aransas Bay. All the other bay records come from the lower bay near or in the pass leading to the Gulf. The lowest salinity at which the fish was caught was 17.4 and the highest was 37.2. Table 4 shows that only 3.2 per cent of the moonfish were taken in water below 30.0 parts per thousand salt. Evidently this species lives in water of high salinities. Hildebrand and Schroeder (1928) reported the moonfish as being present only in the lower part of Chesapeake Bay.

Selene vomer (Linnaeus). Lookdown

Six specimens of the lookdown were caught. Three were taken in lower Aransas Bay in trawls in July and September, 1941 and three were taken in seines on the Gulf beach in October, 1941. The size range of the fish was from 49 to 123 mm. in length. The temperature range at the hauls was 28.8° to 29.5° C. and the salinity range was from 30.9 to 33.7.

Hildebrand and Schroeder (1928) found the lookdown only near the mouth of Chesapeake Bay during September and October. The writer (Gunter, 1938c) did not take the lookdown at all in the bays in Louisiana, but it was found much more abundant in the Gulf during two fall seasons than in Texas. Baughman (1941b) lists this species as being "not especially common in Texas."

Chlorosocombrus chrysurus (Linnaeus). Bumper or Yellowtail

One hundred and forty-four specimens were caught, 67 in Aransas Bay and 77 in the Gulf of Mexico. One hundred and twenty-two fish were taken in trawls and 22 in beach seines. Table 31 shows that the fish was taken only in the summer and fall. The temperature range where bumpers were caught was from 25.4° C. to 30.0° C. It has been found in Louisiana (Gunter, 1938c) that the fish was present only in the summer and fall in the bays and the same thing held true for Gulf hauls except for a few caught in December and a catch in March.

The smallest fish caught was 66 mm. long and the largest was 205 mm. long. In August, 1941 fish ranged in size from 68 to 178 mm. long, one group having a mode at from 73 to 78 mm., while a second group had a mode at from 143 to 148 mm. In the other months the fish ranged variously from 108 to 205 mm. long and the small fish were not found.

The lowest salinity at which specimens were caught was 16.5 and the highest was 37.2. Table 4 shows that the distribution of the fish at the various salinities was somewhat peculiar. Apparently a group of smaller fish came into the bay when the salinity was low. Figure 8 shows that smaller fish were taken in water of the lower salinities.

One ripe female, measuring 171 mm. long, and 3 ripe males measuring 137, 155 and 177 mm. long were taken in a trawl 5 miles SSE of Aransas Pass in the Gulf of Mexico on August 30, 1941. The eggs and milt were oozing out of the fish. The temperature of the water was 27.0° C. and the salinity was 36.7. Five ripe females from 155 to 205 mm. long were taken on June 5, 1942 on the Gulf beach. The temperature was 29.0° C. and the salinity was 30.2.

Trachinotus carolinus (Linnaeus). Common Pompano

The pompano is recognized as an excellent food fish. A yearly average of 7,402 pounds have been reported by commercial fishermen for the past 5 years on the Texas Coast.

Five hundred and fifty-six common pompano were caught, all of them on the Gulf beach. Twenty-one fish were caught in large seines and 535 in minnow seines. The pompano is largely a denizen of the surf. The young are never taken in the bays, although it would not be surprising to find them in the passes. Large fish are sometimes taken in the bays by commercial fishermen, but most of the catch is on the Gulf beach. The fish easily leap over the seines and get away. For the years 1936–37 and 1939–40 to 1941–42 the commercial fishermen have reported an average of 1,143 pounds and 2,350 pounds of pompano from the bay and Gulf, respectively.

The temperature where pompano were caught ranged from 19.0° to 30.7° C. and the salinity range was 28.1 to 36.7. Two hundred and six fish were caught at below a salinity of 30.0 and 350 were caught at salinities above 30.0.

The fish taken in this survey were all small. The size range was 13 to 185 mm. in length. Some large fish were seen to jump the nets and escape. Table 32 shows the monthly catches. The fish were absent from the Gulf beach from January to

May. The period of greatest abundance is in July, August and September. At the onset of cool weather the young begin to leave the shallow surf, probably migrating out to slightly deeper water not far offshore. Pompano are caught the year around commercially, but in diminished numbers in the winter months.

The smallest fish were present when the young first appeared on the Gulf beach in June. Small fish from 13 to 15 mm. long were present from June to September in 1941 and from June to August in 1942. Fish as small as 23 mm. long were taken every month that the fish were caught except in December, 1942. Apparently the small pompano kept feeding into the catches for an extended time during the summer, and an extended spawning season of several months in the late spring and early summer is indicated. Fish up to 43 mm. long were present every month that fish were caught and during several months fish up to 63 mm. long were taken. In August, 1941 some fish from 93 to 98 mm. were caught. During most months the mode of length-frequency curves was at 23 mm., but it varied from 18 to 33 mm. and in October, 1941 it was at 48 mm.

Small pompano are often predominant in minnow seine hauls on the Gulf beach during the summer, as Baughman (1941b) has previously stated. They are outnumbered by *Harengula macropthalma*, the silver sardine and *Polydactylus octonemus*, the threadfin, at times. Baby pompano are hardy little fish and they live long after other species have succumbed in buckets or on the dry sand. It is usual with them to have their stomachs stuffed and distended with small larval fishes.

Trachinotus palometa Regan. Banner Pompano

One specimen of the long-finned pompano was caught in a beach seine on Mustang Island, 1 mile north of Corpus Christi Pass on July 6, 1941. It measured 27.5 cm. in length. The temperature of the water was 29.0° C. and the salinity was 35.7. The faint, narrow vertical bars on the fish did not show up until after it had been kept in formalin several days.

Fourteen small pompano, thought to be this species, ranging from 15 to 43 mm. in total length were taken in minnow seines on the Gulf beach of Mustang Island, near Aransas Pass, in August and September, 1941. The identification is not certain.

The banner pompano is not common in Texas and according to Hildebrand and Schroeder (1928) it is not very common anywhere. Fowler (1931) has previously reported this fish from Texas on the basis of 2 specimens taken near Corpus Christi.

Oligoplites saurus (Bloch and Schneider). Leatherjacket

Nine specimens of the leatherjacket were caught in minnow seines. One was caught in November, 1941 in Copano Bay. Three were caught in August, 1941 in Aransas Bay and 5 were taken on the Gulf beach of Mustang Island in November, 1942. Two of the fish taken in August, 1941 were 30 and 41 mm. in length. The other six specimens ranged from 64 to 100 mm. in total length. The water temperature range at the stations was from 19.5° to 31.8° C. The salinity range was from

9.1 to 32.4. Evermann and Kendall (1894) previously reported the species from the Galveston Bay area, St. Joseph Island and Corpus Christi. Apparently it is never very numerous.

Pomatomidae. Bluefishes

Pomatomus saltatrix (Linnaeus). Bluefish

One little bluefish 38 mm. long was taken in Aransas Bay, October 9, 1941. The temperature of the water was 28.0° C. and the salinity was 19.5. Two more fish, 17.0 and 20.0 cm. long were taken in a trammel net in upper Aransas Bay on April 28, 1942. The temperature was 23.2° C. and the salinity was 17.7.

Baughman (1941b) says this fish used to be common enough to support a small fishery at Galveston, but that it is not common at present. This seems to be true for the whole coast. The Game, Fish and Oyster Commission reported 395 pounds of bluefish as commercial production for the fiscal year 1937–38. They were taken in May and July. No other bluefish have been reported from 1936 to 1942.

Serranidae. Sea Bass

Centropristes philadelphicus (Linnaeus). Rock Sea Bass

Seven specimens of this small sea bass were taken in trawls in sixty to seventy feet of water in the Gulf of Mexico, near the Whistling Buoy, 5 miles SSE of Aransas Pass. They were taken in the months of August and September, 1941 and March and May, 1942. The size of the fish ranged from 84 to 127 mm. in total length. The temperature range of the water was 16.9° to 29.5° C. and the salinity range was from 33.6 to 36.7 parts per thousand.

Weed (1937) has given the range of this species as South Carolina to Louisiana. He says it seems to be more of an offshore species than the larger and better known *Centropristes striatus* (Linnaeus).

Lobotidae. Tripletails

Lobotes surinamensis (Bloch). Tripletail or Sunfish

Records of this species in Texas and northern Mexico have been given by Baughman (1941a, 1943). Woods (1942) has recorded 3 Texas specimens. The fish is not common, but neither is it extremely rare.

One specimen 45.5 cm. long was caught in a trammel net at Frandolig's Point, upper Aransas Bay, on June 19, 1942. It had spent ovaries and had eaten 5 blue crabs, *Callinectes sapidus*. The temperature was 29.3° C. and the salinity was 20.0 parts per thousand. Baughman (1941a) says the fish displays a good deal of indifference to salinity of the water. Gudger (1931) gave evidence that the fish spawns in August in the waters of North Carolina and Georgia. Baughman *(op. cit.)* reports that at Freeport, Texas the fish "contain spawn" in June, July and August, but after that the roe is slight or absent. The papers cited show that this fish eats a variety of fish and crustacea. Baughman *(op. cit.)* says that in the spring the tripletail is reported to frequent the beaches where it feeds on crabs.

The tripletail is noted for its habit of floating near the surface of the water. They usually float on their sides, but I saw one specimen in Aransas Bay floating head downward and tail up.

Lutianidae. Snappers

Lutianus griseus (Linnaeus). Gray Snapper

One dead specimen, 64 mm. long, was taken in a trawl at Ninemile Point, Aransas Bay on January 14, 1942. The water temperature was 9.1° C. and the salinity was 16.1. The fish was taken following a cold spell. Several other dead fishes were taken in the bays at this time and presumably the snapper had been killed by the cold.

The gray snapper is the only lutianid known to enter Texas bay waters. One other specimen from upper Aransas Bay was brought to me by fishermen.

Haemulidae. Grunts

Conodon nobilis (Linnaeus). Barred Grunt

This fish is sometimes seen in the summer around piling or jetties of the passes, but it is not common. In Texas it is at the northern part of its range. One specimen, 104 mm. long, was caught in a trawl 2 miles SSE of Aransas Pass on August 30, 1941. The temperature was 30.0° C. and the salinity was 36.7 parts per thousand.

Orthopristes chrysopterus (Linnaeus). Pigfish or Piggy Perch

Two hundred and ninety pigfish were caught, 223 in Aransas Bay and 67 in the Gulf of Mexico. Six fish were caught in trammel nets, 11 in minnow seines and 273 were taken in trawls. This species was taken at all seasons of the year, as is shown by table 33. It was found to be most abundant in the Gulf in November, possibly after leaving the bays, and most abundant in bays in the spring.

The temperature range at which the pigfish was caught was from 13.7° to 33.0° C. The salinity range was from 10.3 to 36.7. Table 4 shows that 85.9 per cent of the fish were caught at salinities above 25.0 parts per thousand and only 3 fish were caught below a salinity of 15.0. The size range of specimens caught was from 44 to 227 mm. All fish below 50 mm. in length and all above 200 mm. were taken in water above 25.0 parts per thousand salt.

On March 14, 1942 ten ripe males ranging from 134 to 156 mm. in length were caught in Lydia Ann Channel. On April 20, 1942 another ripe male 181 mm. long was taken at the same place. Hildebrand and Schroeder (1928) state that the pigfish spawns in June in Chesapeake Bay. In Texas the spawning season comes earlier. Length-frequency curves showed that fish from 43 to 63 mm. long appeared in June, 1941. In July this group was from 88 to 103 mm. long and a second group from 158 to 193 mm. long were taken. Thereafter only fish from 103 to 213 mm. long were taken scatteringly until January, 1942, when the size of pigfish caught ranged from 103 to 148 mm. in length. Only 3 fish were taken in December and the same group was present in March and April. In the latter month the size

range was from 113 to 158 mm., with one fish at 183 mm. In June this group disappeared and the small fish from 43 to 63 mm. long came into the catch again. As in the previous year they grew rapidly and the smallest fish taken in August, 1942 was 73 mm. long. The upper size limit was 203 mm. The smallest fish were all taken in Aransas Bay.

No very large pigfish were taken in this work. Large specimens are not common in Texas waters and it is little used for food, although a few are sold for that purpose, but it is highly valued as bait. There is some evidence that 50 years ago the pigfish was marketed in greater quantity on the Texas Coast (Gunter, 1944).

Sparidae. Porgies.

Lagodon rhomboides (Linnaeus). Pinfish

Nine hundred and seven pinfish were caught at all seasons of the year. Twenty-four fish were caught in the Gulf of Mexico, 630 in Aransas Bay and 253 in Copano Bay. Three hundred and ninety-seven fish were caught in trawls, 391 in minnow seines and 119 in trammel nets. They were caught at all stations, except on the Gulf beach.

The fish was taken in least numbers in the winter and spring months, especially in December, and was found to be most abundant in the summer and early fall, especially in August and September. This is shown in table 34. The fish were not caught in Copano Bay from December to March inclusive and were scarce in Aransas Bay in December. The pinfish was taken only in the Gulf in November and January. The pinfish moves into deeper water with the onset of cool weather. The temperature range at stations where the pinfish was caught was from 9.1° to 34.9° C.

The pinfish was caught in water ranging from 2.1 to 37.2 parts per thousand salt. Table 4 shows that this fish is rather indifferent to the salinity of the water. No relation between the size of the fish and the salinity of the water was detected.

Spawning or ripe individuals were not noted. The size of specimens measured ranged from 14 to 225 mm. in total length. The smallest specimens first came into the catch in January, 1942 and continued to come in until March. They first appeared in Aransas Bay and were not caught in Copano Bay at that time. They were from 13 to 33 mm. long. Later a few of the smaller pinfish were taken in Copano Bay. A few large fish from 103 to 148 mm. long were also taken in January and throughout the summer. The size of the fish increased from April to October. During the latter month the size of fish caught was from 63 to 203 mm. in length. Reverting back to the previous year, length-frequency curves showed a group of fish from 103 to 143 mm. long in May. In June a smaller group from 43 to 103 mm. long was caught. By July these two groups had practically fused and the smallest fish was 58 mm. long. The upper size limit began to decrease in September, while the lower continued to increase and by November, 1942 the fish caught measured from 93 to 128 mm. long, with a mode at 118 mm., except for two fish at 163 and 223 mm. in length. Only one fish was taken in December, and a few of the same size group noted in November were present in January when the small fish, referred to above, entered the catch.

The time of appearance of the young indicates that spawning takes place in the winter. Bean (1903) has stated that this is the case and Hildebrand and Schroeder (1928) say that the time of appearance of the young in Chesapeake Bay indicates that the fish is a winter spawner. Probably the fish spawns in the open Gulf near the passes.

The stomach contents of 8 pinfish, ranging in size from 15.0 to 28.5 cm. long, were examined. One of them contained razor clam shells and the other 7 contained plant material in the form of algae or grass. Lack of plant material on the Gulf beach probably accounts for the absence of the pinfish in that environment. Hildebrand and Schroeder *(op. cit.)* state that vegetable debris seems to be the most important food, on the basis of 13 stomach examinations. Evidently this fish is largely a grazer. The structure of the teeth also indicates that this is the case.

Archosargus probatocephalus (Walbaum). Sheephead

Twenty-five sheephead were caught in trammel nets. Eight were caught in Copano Bay and 17 in Aransas Bay. The sheephead was caught in the months of July and November in 1941 and in January and August, 1942. In Aransas Bay it was taken in July, September, October and November, 1941 and October, 1942. The greatest number caught in any one month was six. Table 4 shows that most fish were caught at low salinities. The salinity range where sheephead were caught was from 2.2 to 29.9. The highest temperature at which the fish were caught was 30.0° C. and the lowest was 16.0° C. The smallest fish caught was 115 mm. long and the largest was 405 mm. long. No spawning individuals were noted.

The stomach contents of 18 sheephead, ranging in size from 19.0 to 36.5 cm. in length, were examined. Eleven of them contained large balls of plant material, (grass or algae), 2 contained plant materials and crabs, 1 contained plant material and gastropod shells, 1 contained plant material and unidentified shell, and 3 contained blue crabs, *Callinectes sapidus*, only. The sheepshead has a very large body cavity, with a long digestive tract, which was usually found distended with plant materials, while animal food was very much less in volume. For that reason the writer believes that the fish is largely herbivorous. Hildebrand and Schroeder (1928) say that it feeds chiefly on mollusks and crustaceans.

For reasons unknown the sheephead has declined greatly in numbers for many years on the South Atlantic and Gulf Coasts. Hildebrand and Schroeder *(op. cit.)* stated that the sheephead was formerly an important commercial species in Chesapeake Bay, but that it declined until it had almost entirely disappeared. Collins and Smith (1893) gave the commercial production of sheephead for Texas in the years 1889 and 1890 as 738,720 and 778,800 pounds, respectively. From 1938 to 1941, according to the reports of the Game, Fish and Oyster Commission, the Texas annual production of sheephead has averaged 8,055 pounds.

Gerridae. Mojarras

Eucinostomus californiensis (Gill). Silver Mojarra

Eucinostomus gula (Cuvier and Valenciennes). Common Mojarra

Since there seems to be come confusion about the status of the mojarras on our coast, since the two species named possibly intergrade (see Hildebrand and Schroeder, 1928), and since the writer's opportunities for taxonomic work were limited, I have lumped together the two species, which I believe commonly occur, without attempt at separation, thus following the usage of Meek and Hildebrand (1925) and Hildebrand and Schroeder (1928), which procedure was questioned by Hubbs (1936).

Four hundred and forty-three mojarras were caught in the summer, fall and early winter, but not in late winter and spring, except for one fish caught in April. In Copano Bay the fishes were taken only in the months of October, November and December, 1941. In Aransas Bay they were taken in April, 1941, June to December, 1941, and in June and August, 1942. In the Gulf of Mexico mojarras were taken only in August, September and October, 1941 and October, 1942. No fish were taken from January to May, 1942. Fifteen fishes were caught in Copano Bay, 419 in Aransas Bay and 9 in the Gulf of Mexico. Fifty-five fishes were caught in trawls and 388 in minnow seines. These two little mojarras apparently frequent the shores in preference to deep water. Two hundred and sixteen specimens were taken in September, 1941 and 303 were taken from September to December, 1941.

The size range of specimens was 10 to 103 mm. in total length. The temperatures at which the fishes were caught ranged from 14.2° to 32.0° C. and the salinity ranged from 8.7 to 37.1 parts per thousand. Two hundred and fifty-four fishes, 57.3 per cent of the whole, were caught in water above 30.0 parts per thousand saline and only 8 fish were taken in water with a salinity below 10.0.

Gerres rhombeus Cuvier and Valenciennes. Mojarra

Twenty-seven specimens of this West Indian mojarra were taken in trawls at the Bell Buoy and Whistling Buoy in the Gulf, 2 and 5 miles SSE of Aransas Pass, respectively. Only 3 fish were taken at the shoreward station. The fish were taken in September, October and November, 1941, only 1 specimen being taken in the latter month. The size range was from 67 to 92 mm. in length. The temperature range of the water was from 18.4 to 29.5. The salinity range was from 30.6 to 36.6 parts per thousand. This is the first record of the species from the United States.

Mullidae. Surmullets and Goatfishes

Upeneus martinicus Cuvier and Valenciennes. Yellow Goatfish

Three yellow goatfish were taken in a trawl at the Whistling Buoy in the Gulf, 5 miles SSE of Aransas Pass on August 30, 1941. Four more were taken at the same station on May 25, 1942. The size range of the fish was from 68 to 125 mm.

in length. The temperatures of the water were 23.3° and 27.0° C. and the salinities were 36.7 and 33.6, respectively.

Sciaenidae. Croakers and Drums

Larimus fasciatus Holbrook. Banded Drum

One fish 34 mm. long was taken in a trawl at the Bell Buoy in the Gulf of Mexico two miles SSE of Aransas Pass on March 13, 1942. The temperature was 15.4° C. and the salinity was 35.2. Three more specimens measuring 72, 76 and 90 mm. in length were taken at the same station on May 25, 1942. The temperature was 23.5° C. and the salinity was 26.7. This species was found to be much more uncommon in Texas than in Louisiana. There 215 fish were taken in 422 trawl hauls (Gunter, 1938a), while here only 4 fish were caught in 109 hauls.

Bairdiella chrysura (Lacépède). Silver Perch or Yellowtail

Two hundred and thirty-six yellowtails were caught, 50 in Copano Bay, 163 in Aransas Bay and 23 in the Gulf of Mexico. Thirty-five fish were caught in minnow seines and 201 in trawls. They were caught at all months of the year. The fish was almost entirely absent from Copano Bay from November to March and none were taken in either bay in January and February. No fish were taken in the Gulf except in November and January. There seems to be a general exodus of the yellowtail from bay to Gulf waters in the fall and winter. Table 35 gives the monthly catches. The temperature where yellowtails were caught varied from 13.7° to 30.5° C. and the salinity varied from 2.1 to 33.7. Table 4 shows that the fish is more or less indifferent to the salinity. Figure 9 shows that the smallest fish were mostly taken in the less saline water.

Hildebrand and Schroeder (1928) say this fish spawns in late spring and early summer in Chesapeake Bay. Pearson (1941) found planktonic young in June in the same area. According to Welsh and Breder (1923) the height of the spawning season is in May in North Carolina and June in New Jersey. Hildebrand and Cable (1930) state that the spawning season is April, May and June at Beaufort, North Carolina. The writer found fish in Louisiana ripe enough for stripping in April, May and June (Gunter, 1938c). One female with eggs oozing out was taken April 20, 1942 in the middle of Copano Bay. It was 138 mm. long. The temperature was 23.3° C. and the salinity was 14.3.

Table 36 gives the size range of the yellowtails for each month. The smallest fish appeared in June and July in 1941. They were not noted in 1942. All fish below 58 mm. in length were taken in Aransas Bay and apparently spawning and early development took place there and not in the saltier water of the Gulf or the more brackish water of Copano Bay.

Summary: The fish spawns in the spring in the waters of the coastal lagoon. It invades the back bays chiefly in the spring and summer, but is absent from the coastal lagoon only in the late winter, when it is caught in the Gulf. The species is largely euryhalin.

Stellifer lanceolatus (Holbrook). Star Drum

This fish was taken only in trawls. Four hundred and one were caught. Six fish were taken in Copano Bay, 106 in Aransas Bay and 289 in the Gulf of Mexico. The star drum was caught at all seasons at temperatures ranging from 9.1° to 30.5° C. It was caught at salinities ranging from 8.9 to 36.7. Table 4 shows that 72.0 per cent of the fish were taken in water with a salinity above 30.0 and only 1 fish was caught below a salinity of 10.0. The star drum prefers salt water. The very smallest fish were caught at high salinities and probably spawning is in the lower bay or Gulf. No fish larger than 95 mm. in length was taken where the salinity was below 15.0.

The time of greatest abundance was found to be in the late fall and spring with few fish caught in the summer and early fall. No fish were caught in the bays in January and February. Table 37 shows the monthly catch.

According to Welsh and Breder (1923) spawning is in late spring and early summer on the Atlantic Coast. Hildebrand and Cable (1934) say that spawning is in the summer at Beaufort, North Carolina. In Louisiana it was found that females ripe enough for stripping were taken in April, May and June (Gunter, 1938c). On April 22 and 23, 1942, 4 ripe females were taken, 1 in Lydia Ann Channel and 3 at 2 miles and 5 miles SSE of Aransas Pass. They ranged from 130 to 137 mm. long. The temperature range at the 3 stations was from 20.5° to 20.9° C and the salinity range was 28.5 to 30.7.

Only one size group of fish, from 93 to 123 mm. long, was taken in June, 1941. The fish practically disappeared from the catches in July, August and September and in October two size groups were present. One of these, the young of the year was from 38 to 68 mm. long, and the other was from 93 to 133 mm. long. In November the smaller group was 58 to 83 mm. long and the larger group was 93 to 133 mm. long. This latter group had been present since June, but it was caught in small numbers. Rapid growth of the small group took place until January, when either it became blended with the larger group or that class had entirely disappeared. In March and April the size range of fish was from 83 to 143 mm. in length. The fish were probably then in the second year. The fish then virtually disappeared as during the previous summer. Hildebrand and Cable (1934) state that the young reach a length of from 100 to 125 mm. "during the first summer." Evidently they were not counting the summer when spawning takes place, and the fish referred to were one year old. Since the fish seems to spawn in the spring on the Gulf Coast, this is really the second summer of their life. In Texas the star drum reaches a length of from 83 to 118 mm. by April, when they are about a year old, and reach maturity early in the second year of their life. Welsh and Breder *(op. cit.)* gave 70 to 100 mm. as the length of one year old fish and stated that maturity was reached in one year. The largest fish they examined was 16.0 cm. long and 2½ years old. Hildebrand and Cable *(op. cit.)* give 165 mm. as about the maximum length. The largest fish taken in this work was 170 mm. long. Evidently the life history is short.

Welsh and Breder *(op. cit.)* stated that the star drum is one of the most abundant fishes of the South Atlantic and Gulf Coasts. The writer (Gunter, 1936, 1938a) found that in Louisiana it was exceeded only by the croaker, *Micropogon undulatus* (Linnaeus), in trawl catches. There 11,857 star drums were caught in 422 trawl hauls. Here only 401 fish were caught in 109 trawl hauls. The star drum is less abundant on the South Texas Coast than it is farther eastward.

Sciaenops ocellata (Linnaeus). Redfish or Channel Drum

Three hundred and fifty-seven redfish were caught, 229 in Copano Bay, 121 in Aransas Bay and 5 in the Gulf. Two fish were taken in trawls, 5 in beach seines, 34 in minnow seines and 314 in trammel nets. Redfish are practially never taken in trawls and the 2 taken here were caught after a severe cold spell (see below). Furthermore, redfish are seldom taken in minnow seines except when they are in the smallest stages or when the water is extremely muddy. Table 38 shows the monthly catches with various gear. It is seen that the greatest numbers of fish were caught in the fall and winter with few fish taken in the spring and early summer. The commercial catch is least in the spring.

The redfish was caught at temperatures ranging from 8.1° to 32.0° C. and at salinities from 2.1 to 32.4. Table 4 shows that the fish was caught in greatest numbers at salinities below 15.0 parts per thousand.

The annual catch of redfish on the Texas Coast from 1936 to 1942 varied from 215,488 pounds to 851,242 pounds and averaged 540,211 pounds a year. Only 7.8 per cent of the commercial catch of this fish on the Texas Coast during that time came from the Gulf.

No fish with developed gonads were caught. These fish are very rare in the bays. A man who has been a commercial fisherman on this coast for 50 years told the writer that he had only taken two in the bays with roe during that time. Pearson (1929) caught a school of redfish with developing roe near Corpus Christi Pass in Corpus Christi Bay in September. Actual observations on spawning redfish have not been reported, but large fish are known to congregate on the Gulf beach near the passes in the fall and Pearson (1929) says there would appear to be no doubt they spawn there. Pearson took small redfish near the passes in this region in October and November, 1926 ranging in size from 6 to 63 mm. long. On October 13 and November 10, 1941 the writer took 25 specimens in a minnow seine in Lydia Ann Channel, ranging in size from 17 to 58 mm. long. Two more were taken in January measuring 33 and 50 mm. long. In February, April and May, 1942, 7 specimens were taken in minnow seines in lower Aransas Bay ranging in size from 92 to 148 mm. long. These data are in agreement with those of Pearson *(op. cit.)*. He concluded that the spawning season was chiefly in October. It probably extends from the last of September to the first half of November. Pearson concluded that spawning ended about mid-November.

Table 39 shows the size of fish caught at the various seasons. Fish come into the catches in the summer when they are approximately 30 cm. long. According to Pearson *(op. cit.)* fish at this length are about a year old. Apparently in

October they were around 40 cm. in length (according to Pearson fish of this size are from a year to two years old) and a year later they were around 60 cm. in length. Only 2 fish above 74 cm. in length were caught. The very largest redfish were doubtless never taken. They are too strong to be caught in trammel nets and they probably are rare.

The stomach contents of 237 redfish were examined. They ranged in size from 24.5 to 74.5 cm. in length. Thirty-eight were empty and 3 contained an already digested, soupy material. Algae were found in 8 stomachs and grass was found in 6 stomachs. Algae and grass alone were found in 2 stomachs. This plant material is probably taken incidentally with other food, but it was found often enough to be included as an article of diet. The remaining 194 fish had eaten fish 49 times and crustacea 177 times. Fish only were found in 20 stomachs and crustacea only were found in 146 stomachs. Peneid shrimp were taken 95 times, blue crabs *(Callinectes sapidus)* 87 times, grass shrimp *(Palaemonetes vulgaris)* 31 times, oyster or mud crabs (*Panopeus herbstii* Milne Edwards, and *Neopanope texana texana* Stimpson) 20 times, amphipods 8 times, snapping shrimp (*Crago* sp.) 7 times and mud shrimp *(Calianassa jamaicense louisianensis)* 2 times. Peneid shrimp were taken alone 40 times and blue crabs were taken alone 40 times. The peneid shrimp were made up of two species, the commercial shrimp, *Penaeus setiferus* (Linnaeus) and the closely related species, *P. aztecus* Ives. The former was identified 13 times and the latter species 52 times in the stomach contents of redfish. The blue crab exceeded any other species in number of times found in the stomach and in volume it was far greater than any other food. It is the principal food of the redfish. Fish with empty stomachs are usually found with crab claws and shells in the gut. Crabs up to 10.0 cm. in carapace width were eaten. Pearson *(op. cit.)* states that the commercial shrimps *(Penaeus)* are the chief article of food of the redfish, with the crab ranking second in importance. However, he dealt in part with smaller fish than those examined here, and apparently did not differentiate the peneid shrimp, calling them all commercial shrimp, and he may have based his conclusions on the number of times shrimp were eaten for nothing was said of volume. Only one of the peneids, *P. setiferus*, is of commercial importance and the writer found that it ranked below *P. aztecus* in the number of times eaten. Pearson reported finding squid, annelid worms and bivalves in redfish, which I did not find, and he did not report amphipods, grass shrimp *(Palaemonetes)* and mud crabs *(Panopeus* and *Neopanope)*, which I found many times. Possibly this discrepancy is due to the fact that most of the fish I examined came from Copano Bay, a back bay, while most of Pearson's fish came from in or near the Gulf. It is interesting to note that such small organisms as the grass shrimp and the still smaller amphipods were eaten. One fish 42.5 cm. long had eaten 82 grass shrimp. Amphipods were not counted, but in some instances a small handful was found in redfish stomachs.

Of the fish eaten mullet were identified 6 times, eels 5 times (one definitely as *Myrophis punctatus*), gobies 5 times (one definitely as *Gobiosoma bosc*), *Cyprinodon variegatus variegatus* 3 times, pipefish twice, *Anchoa mitchilli diaphana* twice, *Galeichthys felis* once, *Lucania parva venusta* once, *Leiostomus xanthurus* once and

Symphurus plagiusa once. Mullet six inches long were eaten by redfish 18 inches long. A hardhead catfish 8 inches long was eaten by a redfish 20 inches long.

Pearson has concluded that the redfish is intermediate between a bottom and pelagic feeder. The fact that it eats mud crabs, which cannot swim and the mud shrimp, which burrow in the mud, indicates that it feeds on the bottom partly. A reputable commercial fisherman, Mr. Willie Close, told me that in the summer of 1943 he caught a redfish in Aransas Bay, weighing 9 pounds, which had no eyes. According to him it had no eyesockets. The fish was reported to have been fat. The writer did not see the specimen, but if the story is to be credited, then the fish must have been purely a bottom-feeder.

Leiostomus xanthurus Lacépède. Flat Croaker or Spot

Twelve hundred and sixty-four flat croakers were caught, 1,021 in trawls, 100 in minnow seines and 143 in large nets. One hundred and forty-seven fish were taken in Copano Bay, 841 in Aransas Bay and 276 in the Gulf of Mexico. The size range of specimens was from 25 to 282 mm. in length. The temperature range at which the fish were taken was from 8.1° to 32.0° C. and the salinity range was from 2.0 to 36.7. Table 4 shows that fish were taken in numbers over a wide salinity range, but they were most abundant above a salinity of 15.0 parts per thousand.

Welsh and Breder (1923) stated that the spawning period for this fish was late fall and early winter and appears to be the same in both Atlantic and Gulf waters. Hildebrand and Schroeder (1928) stated that in Chesapeake Bay spawning took place in late autumn and probably in winter and apparently at sea, for they noted a general exodus from the bay of large fish with developing roe during September and October. Pearson (1929) observed this fall migration of ripening adults in Texas, but said it was not so pronounced as along the Atlantic Coast.

Pearson concluded, chiefly, it appears on the basis of the time of appearance of the young, that spawning took place from December to March in the Gulf near the passes and that the young rapidly spread into the bays and lagoons. He took specimens near the passes ranging in size from 7 to 14 mm. long, from December 23 to March 30. In April, 1942 the writer took several fish in Aransas Bay from 25 to 30 mm. long. Four fish ranging from 205 to 229 mm. long, with small roe were taken in Copano and Aransas Bays on October 23, 1941. A fish 220 mm. long with medium developed yellow roe was taken on the same date. On October 29, 1942 five females, ranging in length from 200 to 228 mm., with small yellow roe were taken in Aransas Bay. Another fish 210 mm. long, taken at the same time, had larger, but not fully developed, yellow roe. On November 5, 1941 five males, ranging from 245 to 270 mm. in length, with large milt, were taken on the Gulf beach of Mustang Island, one mile from Aransas Pass. Thirteen females, ranging in size from 245 to 270 mm. long, having large yellow roe were taken in the same haul. Three males, 200 to 235 mm. long, with milt and a female, 210 mm. long, with fully developed roe were taken on the Gulf beach of Mustang Island on January 22, 1942. Six males, 200 to 220 mm. long, and 3 females, 215 to 245 mm. long, with spent gonads were taken at the same time.

The flat croaker does not often reach large enough size to be of commercial importance in Texas. A few are sold under the head of scrap fish, and statistics on the production are not available in the Marine Products Reports of the Game Fish and Oyster Commission. According to U. S. Fish and Wildlife Service statistics (Fiedler, 1938, 1940, 1941, 1942 and 1943) the Texas catch from 1936 to 1940 varied, from none reported in 1939 and 1940 to 12,000 pounds in 1937, with an average of 4,960 pounds produced annually for the five year period.

Length-frequency curves showed that small fish came into the catch in April, 1942 at a length of from 23 to 93 mm. A larger group of fish which could be traced in the catch from the previous January was taken at the same time. The size range was from 143 to 203 mm. in length, with a mode at 158 mm. Both groups increased in size and in August the smaller ranged from 73 to 138 mm. in length with a mode at 118 mm. Only a few of the larger group remained. They then measured from 193 to 233 mm. long. During the previous year two sizes were present in June, 1941. The length ranges, 68 to 98 mm. and 143 to 173 mm., were somewhat different from those in 1942. Thereafter fusing and overlapping of the groups took place and the curves became irregular. Fish from 113 to 243 mm. long were present in January. Very few fish in the group from 240 to 270 mm. long were taken. Hildebrand and Schroeder (1928) and Welsh and Breder (1923) stated that fish from 260 to 280 mm. long are probably in their third year. The fact that few flat croakers above 250 mm. long were found in Texas waters led Pearson (1929) to the conclusion that the flat croaker does not survive after spawning. Pearson only took 3 out of 3,471 fish that were over 250 mm. in length. The writer found 15 fish out of 1,264 that were from 255 to 282 mm. long. This is a much higher percentage than Pearson found, but it is still very small and tends to corroborate, rather than invalidate his theory.

Table 40 shows that this fish was found in Copano Bay in the spring and summer. Few were taken in Aransas Bay in the winter and the fish were taken in larger quantities in the Gulf in trawls in January. The fish seem to largely leave the bays in midwinter and go into the Gulf.

The stomach contents of six fish from 200 to 212 mm. long were examined. Three of them were empty, one contained indistinguishable material, and one had eaten amphipods. The other fish had grass in the intestine. Welsh and Breder *(op. cit.)* said that the spots had principally small crustaceans, such as amphipods and ostracods, in their stomachs. Hildebrand and Schroeder *(op. cit.)* found the stomach contents consisted of minute crustaceans and annelids, and some mollusks, with fish and vegetable debris.

Micropogon undulatus (Linnaeus). Croaker

There were 15,857 croakers taken in this project. One thousand one hundred and sixty-two were taken in the Gulf of Mexico, 5,481 in Aransas Bay and 9,214 in Copano Bay. One hundred and twenty-seven fish were taken in trammel nets and beach seines, 302 in minnow seines and 15,428 in trawls. The size range of specimens was from 14 to 370 mm. in length. The temperature range where fish were caught was from 9.1° to 32.0° C. The lowest salinity at which the croaker was caught was

2.0 parts per thousand and the highest was 36.7. Table 4 shows that the fish was taken in large numbers at all salinities, but that it was taken in greatest numbers below salinities of 15.0 parts per thousand.

Table 41 shows that the fish was most numerous in the spring, summer and early fall, and relatively scarce in the late fall and winter. The writer (Gunter, 1938c) found the same thing in trawl catches in Louisiana.

The writer has commented before and given data on the great abundance of the croaker (Gunter, 1936, 1938a, 1941b) on the Louisiana and Texas Coasts. Pearson (1929) noted this abundance in Texas and stated that scarcely a locality seined or trawled the bays or open Gulf failed to give large catches.

Pearson found that the croaker spawns in the late fall in the open Gulf near the passes. He stated that a noticeable migration of ripe adults from the bays to the Gulf took place in September and October. The writer found no croakers with ripening gonads in Copano Bay. In December, 1941 one fish 24.2 cm. long, with mature milt was caught in lower Aransas Bay. In October, 1942, 27 females with yellow roe were taken in Aransas Bay. They measured from 21.5 to 30.5 cm. in length. One fish had cream colored roe. Seven males with ripening milt were taken at the same time. They were from 23.5 to 27.0 cm. long. In November and December, 1941 one male 25.0 cm. long and 2 females 24.0 and 30.5 cm. with ripe gonads were caught on the Gulf beach. Three spent fish from 29.5 to 37.0 cm. long were taken at the same time.

In October, December, January and March Pearson took hundreds of small croakers from 3 to 70 mm. long in the passes or scattered out over the bays. The fish entered the passes with incoming tides and were distributed over intercoastal waters. Figure 9 shows that the writer took small croakers from October to April in 1941–42, with the largest numbers taken in February. No fish less than 53 mm. long was taken during May and afterwards. The curves are more or less self-explanatory. Fish which were from 53 to 83 mm. in length in March, 1941 appear to have attained a length of from 103 to 173 mm. in length in October when they were approaching an age of one year. There was some overlapping of sizes of small croakers noted in January, February, March and April. This was no more than would be explained, however, by a long breeding season and a better fortuitous catch in some months than in others or possibly two spawning peaks in a season. My data differ somewhat from Pearson's and the curves show evidence of two distinct groups in May, June and August, 1942 with no intermediates or "strong overlap" as Pearson found. There was indication of a slight overlap in May. My measurements were made in millimeters and the overlap found by Pearson was caused by the fact that his curves were in centimeters. In August the two groups ranged from 83 to 173 and from 213 to 283 mm. long respectively. There is no indication from the curves that these fish belong to anything other than year classes 0 and I, not far from the time when they became year classes I and II, which is from a year to 2 years younger than Pearson *(op. cit.)* judged the age of some fish of these sizes to be. By tracing back the curves, the size of every specimen caught can be related to these two groups, except for some stragglers at 353 to 368 mm. long taken in October and November, 1941. These two fish were probably in year class III. No indications

were found of four year old fish, which Pearson thought he had. The data and this interpretation corroborates Pearson's theory that most croakers disappear following spawning at about the age of 2 years. If the croaker attains a length of 380 mm. in the fourth year of life, then the growth rate must be far slower than that of the closely related flat croaker. A few croakers survive the second year and go on to attain a size of from 4 to 5 pounds on the Texas Coast. They are known as golden croakers. I suspect that such fish are 4 or 5 years old. Pearson made no mention of these large croakers. They run up to about 20 inches in length.

The fact that few fish over 2 years old and 290 mm. long survive is the chief reason why croakers decline in numbers in the fall and winter and also the reason why they are not produced commercially on a large scale in Texas waters. According to federal fishery statistics (Fiedler, 1938, 1940, 1941, 1942 and 1943), Texas produced annually an average of 42,300 pounds from 1936 to 1940. The variation in the yearly catch was from 10,200 to 82,600 pounds.

The stomach contents of 19 croakers, ranging in length from 21.0 to 29.0 cm., were examined. Twelve fish were empty. One had eaten a fish, one had eaten a mud shrimp, *Calianassa,* two had eaten mollusks, one had eaten a shrimp and a crab, and two had eaten crabs.

Menticirrhus americanus (Linnaeus). Shoemaker or Whiting

Three hundred and twenty-six specimens of this whiting were caught, 134 in Aransas Bay and 192 in the Gulf of Mexico. Four fish were caught in trammel nets, 12 in minnow seines and 310 in trawls. The smallest fish was 24 mm. long and the largest was 318 mm. long. The lowest temperature at which the whiting was caught was 13.7° C. and the highest was 30.5° C. The lowest salinity at which the species was taken was 14.4 and the highest was 36.7 parts per thousand. Table 4 shows that the majority were taken in water above a salinity of 30.0.

Table 42 shows that the fish was caught less often in the winter months than during other seasons. The fish apparently practically all left the bay in January and February, although they were present there in previous and following months. Hildebrand and Cable (1934) said this fish becomes scarce in winter, especially during cold spells at Beaufort, N. C. The fish was found to be least abundant in the winter and early spring in Louisiana (Gunter, 1938c).

Hildebrand and Cable *(op. cit.)* said the spawning season at Beaufort extends from April to August and possibly into September. Fish with well-developed roe were taken in April, May and June in Louisiana (Gunter, 1938 *op. cit.*). The spawning season must be long. A fish 27.0 cm. long with roe beginning to develop was taken in Aransas Bay on March 15, 1942. A fish 28.0 cm. long with large roe was taken on November 13, 1941, in the same bay.

Table 43 gives the total length range of specimens taken in both Aransas Bay and the Gulf. The smallest fish were all taken in the Gulf in the months of July and August, and slightly larger fish were taken there in June and November. Apparently the fish spawn and the young stages are gone through in the Gulf.

The stomach contents of 2 fish were examined. One fish 31.0 cm. long had eaten 1 common crab and 1 fish. A whiting 27.0 cm. long had eaten 2 worm eels, *Myrophis punctatus*, 1 grass shrimp and 1 crab.

Menticirrhus littoralis (Holbrook). Surf Whiting

This fish was less commonly taken than *M. americanus* and it seemed to prefer saltier water. Only 3 out of a total of 54 were caught in Aransas Bay. In contrast to *M. americanus* it seemed to prefer the shallows or surf and only 4 fish were taken in trawls. Hildebrand and Cable (1934) said it seldom entered inside waters at Beaufort, North Carolina. Two fish were caught in trammel nets, 2 in beach seines and 46 in minnow seines. The temperature range of the water varied from 13.8° to 30.6° C. and the salinity range was from 17.9 to 36.7 parts per thousand. Table 4 shows that the fish was rarely taken at a salinity below 25.0.

The surf whiting was taken in Aransas Bay during the months of July and October, 1941 and May, 1942. It was caught on the Gulf beach from June to October, 1941, and February, March, August, September and October, 1942. The fish was caught in trawls in the Gulf only in the months of November and January, at the time when it was not caught on the beach, indicating the fish goes to deeper water at the time of low temperatures. Twenty-eight fish were caught in July, August and September, 1941, but only 2 were caught in the months of December, January and February. The fish was also taken less often in the winter than at other times.

The smallest specimen caught was 22 mm. long and the largest was 340 mm. long. One fish, 31.0 cm. long, with well developed yellow roe was taken in lower Aransas Bay on May 30, 1942. Another, 21.0 cm. long, with roe was taken at Caeser's Point in Aransas Bay on July 30, 1941. Fish from 22 to 26 mm. long were taken from June to October. Hildebrand and Cable (1934) say that the indications are that the spawning period is from the first of May into August at Beaufort, N. C. The data collected here indicate that this also roughly conforms to the spawning period in Texas waters.

The stomachs of the 2 fish with roe were opened. Both contained razor clam shells.

Pogonias cromis (Linnaeus). Black Drum

One hundred and seventy-four black drum were caught, 124 in Copano Bay, 35 in Aransas Bay and 15 on the Gulf beach. No fish were caught in trawls and only 3 were caught in minnow seines. The fish was caught at temperatures ranging from 14.9° to 30.7° C. and salinities ranging from 2.6 to 34.9 parts per thousand. Table 4 shows that the drum was most abundant at salinities from 10.0 to 15.0 and more or less equally found at all other salinities.

Table 44 shows that the drum was caught in greatest numbers from October to February. Commercial production records for the Texas Coast from September, 1938 to August, 1943 show that the drum was most abundantly taken in the fall and winter months. From 1936 to 1943 the Texas Coast has produced commercially 1,230,434 pounds of drum a year.

According to Pearson (1929) the black drum spawns principally from February to May and secondarily from July to November near the mouths of the passes on the Texas Coast. The writer took no drums with ripe or developing gonads. Pearson said that young drum had a localized distribution in particular areas. Only 3 small drums, measuring from 81 to 85 mm. in length were caught. They were taken at Richardson's Landing, Minnow Seine Station 8, lower Aransas Bay on June 22, 1942. They were probably spawned about the previous March or February.

The seasonal distribution and movements of the drum are far from clearly known. According to Pearson *(op. cit.)* there is a spawning migration from the bays to the Gulf of Mexico from late January to May. After spawning there is a return to the bays. In this study drums from 20.0 to 53.0 cm. long were taken in Copano Bay with no well-defined seasonal distribution. In Aransas Bay the size of the fish was from 81 mm. to 43.0 cm. long, with no marked seasonal distribution except for 3 small specimens mentioned above. On the Gulf beach the size of drums caught ranged from 21.5 to 37.0 cm. in length.

The stomach contents of 124 fish ranging in size from 20.5 to 46.0 cm. in length were examined. Twenty-one were empty and 9 contained indistinguishable material. Of the remaining 96 fish, 59 had eaten crustacea, 35 had eaten mollusks, and 21 had eaten fish. Twenty-three had eaten amphipods, 21 had eaten blue crabs, 5 had eaten peneid shrimp, 5 had eaten grass shrimp, *Palaemonetes*, 4 had eaten oyster crabs, *Panopeus*, and 1 had eaten a pistol shrimp, *Crago*. Of those fish which had eaten mollusks, 8 had eaten unidentified gastropods, 4 had eaten *Donax* and 1 had eaten a razor clam. All other mollusks were unidentified. Of the drums that had eaten fish, 14 contained gobies, identifiable in 12 instances as *Gobiosoma bosc.* Several fish contained this goby alone, in numbers ranging from 1 to 23. It seemed to be the chief fish food. Several fish contained amphipods alone. The amphipods were less than a quarter of an inch long and it seems remarkable that such small organisms are eaten. The food of the drum was not found to differ greatly from the food of the redfish, except for the molluscan component.

Otolithidae. Weakfish or Sea Trouts

Cynoscion arenarius Ginsburg. Sand Trout

Twenty-five hundred sand trout were caught. Six hundred and ninety-nine fish were caught in Copano Bay, 1,462 in Aransas Bay and 339 in the Gulf of Mexico. Due to the small size of the species only 3 specimens were caught in trammel nets and beach seines. Fourteen fish were caught in minnow seines and 2,483 were caught in trawls. Table 45 gives the monthly catch with various gear.

The lowest temperature at which fish were caught was 13.7° C. and the highest was 36.7°. Table 4 shows that many fish were caught at low salinities but that the greatest number were caught at salinities above 15.0 parts per thousand. Although most of the small fish were caught between salinities of 15.0 and 25.0, probably where spawning took place, there was some direct correlation between the size of the fish and the salinity of the water where they were caught. Table 46 shows the average lengths of sand trout taken at the various salinities.

Only one ripe fish was noted. It was a male 157 mm. long taken in upper Aransas Bay in a trawl on March 29, 1942. The temperature was 17.1° C. and the salinity was 19.3. Gunter (1938c) took ripe fish in April, May and June in Louisiana.

The young from 18 to 38 mm. in length were found in April, May, June and September in Texas. The smallest fish were taken in Copano and Aransas Bays. A long breeding season is indicated. The smallest fish caught was 18 mm. long and the largest was 377 mm. long. Fish above 245 mm. in length were found only in September, October and November, 1941 and October, 1942. During most months the size distribution of the sand trout was very widespread with length-frequency modes ill-defined or lacking. There was a mode at 88 mm. in June, 1941 and one at 93 mm. in July. In August and September there were indications of a mode at 123 and 138 mm., respectively. No more modes could be detected in the following months, but most of the fish caught were between 73 and 178 mm. in length. From September, 1941 to January, 1942 the lower size increased and the upper size limit decreased. In September the limits were from 23 to 377 mm. and in January they were from 73 to 178 mm. The sizes of the fish caught remained about the same until March. In April two size groups were present. Small fish from 23 to 38 mm. long were caught and another group from 103 to 203 mm. in length was taken. Both groups continued in the catches until August, when the larger group had a length-frequency mode at 128 mm.

Table 45 shows that the greatest abundance of the sand trout was in the late summer and in the fall. Examination of the table shows that the abundance of this fish declined between October and November in Copano Bay and was maintained in Aransas Bay, but declined there between November and December. In January the number of fish taken in the Gulf was greater than at any other time. Evidently there is a migration of fish from the bays to the Gulf at the onset of cool weather, beginning first in the back bays in the fall. The size of most fish at the time of greatest abundancce and during the winter was 73 to 183 mm. There seems to be little growth in the winter. It has been shown before (Gunter, *op. cit.*) that in Louisiana there was a decline of numbers of *C. arenarius* in the bays in the fall and winter.

The sand trout is excellent food, but due to its small size it is little used. During some years a thousand pounds or so are recorded as being sold commercially on the Texas Coast.

Cynoscion nebulosus Cuvier and Valenciennes. Speckled Trout

Four hundred and sixty-four speckled trout were caught. One hundred and forty-one fish were caught in Copano Bay, 298 in Aransas Bay and 25 in the Gulf of Mexico. Sixty-two fish were taken in minnow seines, 71 in trawls and 331 in trammel nets and beach seines. Table 47 shows the monthly catches.

The lowest temperature at which the species was caught was 8.1° and the highest was 34.9° C. The salinity range at which it was caught was from 2.3 to 34.9 parts per thousand. Table 4 shows that the speckled trout was caught at all salinities

but the greatest numbers were taken between 5.0 and 20.0 parts per thousand. No special relationship between the size of specimens caught and salinity was found.

According to Pearson (1929) spawning of the speckled trout is in the bays and lagoons and the season extends from March to October. The writer found ripe females as late as November 13, 1941. In 1942 the fish had developing gonads in March but they did not become ripe until April. Fishermen have told the writer that there are two spawning periods for this fish, one in the spring and one in the fall. My data are not conclusive enough to show two spawning peaks. The smallest ripe fish was 30.5 cm. long. Females averaged larger in size than males, as Pearson *(op. cit.)* has shown. Fishermen call all large fish sow trout.

The smallest fish were taken in July, September and October in 1941. They were caught in Aransas and Copano Bays. The next year they were found in June and August. The smallest fish caught was 19 mm. long and the largest was 58.5 cm. long. Two size groups of fish were taken. In June, 1941 a small group from 2.0 to 6.5 cm. in length was taken. It could be followed throughout the summer and fall and in January was 6.5 to 19.0 cm. long. In May the group merged with larger fish. At that time the smallest fish caught were 16.5 cm. in length. In June, 1942 small fish from 2.0 to 6.5 cm. long came into the catch again. A larger group of fish ranging from 31.5 cm. to 51.5 cm. long were taken every month. A length-frequency mode at between 31.5 and 36.5 was detected in most months. From February to June, 1942 fish of 25.0 cm. in length were present and during August and October the size range of this group of fish was from 21.0 to 58.5 cm. in length.

No particular seasonal peak of abundance of this fish was noted except in trawl catches. It was found (Gunter, 1938c) in Louisiana that there was a decided peak in trawl catches during midwinter. The same thing was found here, as is shown in table 47. The only fish taken in trawls in the Gulf were taken in January. Twenty-five fish were taken in the Gulf and on the Gulf beach. All were taken in October, November and January except for one taken in August.

The speckled trout is a very important sport and commercial fish on the Texas Coast. From 1936–37 to 1942–43 the Texas Coast produced commercially each fiscal year an average of 1,236,133 pounds of speckled trout. Of this 1,196,809 pounds came from the bays and 39,324 pounds came from the Gulf beach.

The stomach contents of 153 fish ranging in size from 27.5 to 55.5 cm. in length were examined. Fifty-nine fish were empty and 8 contained indistinguishable material. The following fishes were found to have been eaten by the remaining 93 trout: 28 fish (species not discernible), 18 *Mugil cephalus*, 5 *Menidia peninsulae*, 4 *Cyprinodon variegatus variegatus*, 3 *Brevoortia*, 2 *Lagodon rhomboides*, 1 *Orthopristes chrysopterus*, and 1 *Lucania parva venusta*. This gives the number of times specimens were found in stomachs and not the actual number eaten. The following crustacea were found the following number of times: 20 *Penaeus aztecus* or *duoarum*, 7 *Palaemonetes*, 6 *Callinectes sapidus*, 3 *P. setiferus* and 3 *Penaeus* (*setiferus* or *aztecus* group).

Pearson *(op. cit.)* found that the speckled trout fed largely on shrimp. My data show that they fed mostly on fish, but the discrepancy is due chiefly to the fact

that most of the fish I opened were taken in winter months when shrimp were scarce. There seems to be no doubt that shrimp are preferred and during warmer months the food was found to be largely shrimp. On January 18, 1941, there was a freeze on the coast and shrimp immediately became scarce. Up to that time speckled trout had been feeding largely on peneid shrimp, but after the freeze their food intake changed quickly and mullet became the chief food. The writer found no gobies, such as Pearson found in trout. Probably these little fishes are eaten by small trout which live largely in grass and which I did not open. Trout are voracious and the number found to be empty indicates that digestion is rapid. Five speckled trout contained mullet about half as long as themselves. One fish 44.5 cm. long had eaten a mullet 26.0 cm. long.

Cynoscion nothus (Holbrook). Sand Trout

This sand trout is not differentiated from *C. arenarius* by the lay observer. It has a little more yellow on the fins, so that after some experience the two species can be almost perfectly separated on sight. The body also is much rougher, due to scale differences, than that of *C. arenarius* and the fin rays are much more brittle in the live or fresh fish. Fish coming up in the trawls often have the fins broken and large parts of them missing. Ginsburg (1931b) has given other characteristics differentiating the two species.

One thousand nine hundred and forty-nine *C. nothus* were caught. One hundred and ninety-three fish were caught in Aransas Bay and 1,756 were taken in the Gulf. Table 48 shows the monthly catch. The smallest fish caught was 46 mm. long and the longest was 238 mm. Ginsburg *(op. cit.)* has previously pointed out that this fish is smaller than *C. arenarius.*

The temperature range at which this fish was caught was 13.7° to 29.9° C. and the salinity range was from 18.2 to 36.7 parts per thousand. Table 4 shows that this fish definitely prefers waters of high salinity and it may be said that *C. arenarius* is estuarine while *C. nothus* is marine. Ginsburg (1931b) and Gunter (1938c) have previously pointed out that *C. nothus* is more common in the Gulf and *C. arenarius* predominates in bay areas. Nevertheless, *C. nothus* enters the bays only during the cooler months when salinities are usually lowest, as shown by Gunter *(op. cit.)* and by table 9, and temperature is also probably a factor in excluding this fish from the bays, but not the completely determining one.

The largest fish were taken only in water above 30.0 parts per thousand salt and although the smallest fish were taken in saltier water the average size of fish in water with salinity below 30.0 was smaller. The size range of 165 fish taken at salinities below thirty was from 66 to 143 mm. in length and the length range of 624 fish taken at salinities above 30.0 was from 46 to 238 mm. Of the latter group 103 fish were larger than 146 mm. in length.

A ripe male 208 mm. long was taken in a trawl on August 30, 1941 in the Gulf at the Whistling Buoy, 5 miles SSE of Aransas Pass. The depth was six fathoms. The temperature was 27.0° C. and the salinity was 36.7. The smallest fish were taken in June and November, 1941 in the Gulf of Mexico. The small fish were not

common and only in October and November were they taken in numbers. In November the size range of the group was from 43 to 108 mm. in length, with a length-frequency mode at 78 mm. This group of fish was taken each month, as they increased in size. In March, 1942 the length range was from 53 to 123 mm. and the mode was at 88 to 93 mm. The group was followed until June when the length range was from 113 to 143 mm. In June, 1941 a group of fish ranging from 123 to 153 mm. in length and having a mode at 143 mm. were caught. They could be followed until October, when they disappeared from the catch. They were then 163 to 183 mm. in length. A few stragglers from 193 to 238 mm. long were taken in August and October. Fish of this size were taken again in April and May, 1942. It is seen that the catch consisted chiefly of 2 size groups of fish. The larger group disappeared in October at the time when the smaller fish became more numerous in the catch. Growth is rapid and it appears that fish from 93 to 138 mm. long taken in May were about 1 year old. The fish practically all disappeared from the catches at about what is surmised to be the second winter of their life. They possibly grew too large to be commonly taken by shrimp trawls in the waters of the open sea. Table 48 shows that the greatest abundance of this sand trout fell during March and April.

Ephippidae. Spadefishes

Chaetodipterus faber (Broussonet). Spadefish

Twenty-three spadefish were caught, 1 in Copano Bay, 8 in Aransas Bay and 14 in the Gulf of Mexico. Two fish were caught in trammel nets, 6 in beach seines and 15 in trawls. The size of specimens caught ranged from 62 to 195 mm. in total length. The spadefish was caught from June, 1941 to June, 1942, except in September, December, January, February and May. The temperature range at which it was caught ranged from 17.1° to 29.0° C.

The salinity range at which the spadefish was caught was from 11.1 to 35.8 per mille. Table 4 shows that the firsh preferred water of high salinity. The largest fish were caught on the Gulf beach. Fish caught in the bay ranged from 68 to 135 mm. long and those caught in the Gulf were from 62 to 195 mm. long. The largest fish were caught in waters of high salinity. This fish apparently never grows to as large a size along the Texas Coast as it does in the Chesapeake Bay region, see Hildebrand and Schroeder (1928).

CATAPHRACTI

Scorpaenidae. Scorpionfishes

Scorpaena ginsburgi Gunter. Scorpionfish

One specimen 151 mm. long was taken 2 miles SSE of Aransas Pass in the Gulf of Mexico on November 25, 1941. The water temperature was 17.6° C. and the salinity was 30.6 per mille. The specimen was made the paratype of a new species, see Gunter (1942b).

Triglidae. Sea Robins

The Triglidae of the Texas Coast are fishes of saltier water. Much remains to be done with the taxonomy of this group and with the exception of *Prionotus scitulus* some of the identifications given are provisional.

Prionotus beanii Goode. Sea Robin

One specimen provisionally identified as this uncommon sea robin was taken in a trawl 2 miles offshore in the Gulf of Mexico at the Bell Buoy, SSE of Aransas Pass, on April 22, 1941. The temperature was 20.9° C. and the salinity was 29.7. The length of the fish was 65 mm.

Prionotus pectoralis (Nichols and Breder). Soldier Sea Robin

Three fish were caught in a trawl 5 miles SSE of Aransas Pass on March 14, 1942. The temperature was 17.1° C. and the salinity was 35.2. The lengths of the fish were 103, 138 and 142 mm.

Prionotus punctatus (Bloch). Spotted Sea Robin

Three fish were taken in the Gulf in a trawl 2 miles and 5 miles SSE of Aransas Pass. Two fish were taken at the last location. The dates were January 12 and March 22, 1942. The temperatures were 13.8 and 16.9° C. and the salinities were 28.9 and 33.9, respectively. The specimens were not measured. One specimen 179 mm. long was caught in a trawl in Aransas Bay at Trawl Station 6 on August 22, 1942. The temperature was 30.5° C. and the salinity was 28.0 parts per thousand.

Prionotus scitulus Jordan and Gilbert. Slender Sea Robin.

Sixteen fish were caught, 10 in Aransas Bay and 6 in the Gulf of Mexico. The species was taken only from December, 1942, to April, 1943, except for 3 fish taken in August. The temperature range where fish were caught was from 13.8° to 30.3° C. Except for the 3 fish taken in August none was caught at a temperature higher than 22.4° C. Seven fish were caught at salinities between 25.0 and 29.9 and 9 fish were caught where the salinity was above 30.0. The specimens ranged from 137 to 180 mm. in length.

Prionotus tribulus Cuvier and Valenciennes. Sea Robin

One hundred and three specimens of this fish were caught, 1 in Copano Bay, 32 in Aransas Bay and 70 in the Gulf of Mexico. All fish were taken in trawls. Table 49 shows the monthly catches. No fish was caught in the bays during the winter, but they were caught in the Gulf in January, the only winter month during which trawl hauls were made there. This sea robin was caught in least numbers in the summer. The size of fish caught ranged from 35 to 181 mm. long. The smallest fish appeared in March and April.

The temperature at which the fish was caught varied from 13.7° to 29.5° C. The salinity range was from 10.2 to 37.2. Table 4 shows that the fish preferred waters of high salinity.

GOBIODEA

Gobiidae. Gobys

Gobionellus boleosoma (Jordan and Gilbert). Darting Goby

Fifty-seven specimens of this goby were caught, 2 in Copano Bay and 55 in Aransas Bay. All were caught in minnow seines. The fish were caught in the months from September to January and May. The temperature range at which this goby was caught was from 12.2° to 29.5° C.

Table 4 shows that the fish was most commonly taken between salinities of 15.0 to 30.0 per mille and only 2 fish were caught at a salinity below 15.0.

The size of the gobies ranged from 11 to 44 mm. in length. The smallest fish were taken in December. Ripe females were taken in Copano Bay on November 4, 1941.

Gobionellus hastatus Girard. Sharp-tailed Goby

Two live specimens of this goby were taken in minnow seines in Copano and Aransas Bays on October 17, 1941, and April 12, 1942, respectively. The temperatures were 25.0° and 21.4° C. and the salinities were 6.8 and 13.2. The Copano fish was 25 mm. long and the other was unmeasured. On January 13, 1942, twelve dead sharp-tailed gobies were taken in a trawl in Aransas Bay following a freeze. They ranged from 40 to 103 mm. in length.

Evorthodes lyricus (Girard). Lyre Goby

Thirty-one specimens provisionally identified as this goby were taken in minnow seines. They were all taken in Aransas Bay and all but one were found in the lower or middle bay. Ginsburg (1931a) reports finding the species in the bay near the Gulf in Louisiana. This goby was taken in the months of November, February and March. The size of specimens was from 21 to 41 mm. in length. They were all young fish. The water temperature at the stations ranged from 14.5° to 21.6° C. and the salinity ranged from 13.3 to 31.7. Twenty-two of the fish were taken at salinities above 20.0 per mille.

Gobiosoma bosc (Lacépède). Naked Goby

One hundred and seventy-three naked gobies were caught. They were all identified as *Gobiosoma bosc*, although it is possible that a few of the fish were *G. robustum*. One hundred and five naked gobies were taken in Copano Bay and 68 were taken in Aransas Bay. All fish, except 2 from Aransas Bay caught in trawls, were taken in minnow seines. These little gobies are very common in grassy areas, where they are difficult to catch in nets. The numbers eaten by drum and redfish show that they are much more abundant than the numbers taken in nets indicate. Table 50 gives the monthly catches.

The lowest temperature at which naked gobies were caught was 13.0° C. and the highest was 33.2° C. Table 4 shows that they were most abundant in salinities

between 5.0 and 20.0 parts per thousand and were very uncommon where the salinity was above 20.0.

The size range of specimens was from 16 to 52 mm. in length. Fish below 20 mm. in length were caught in the months of June, October, November and December. They were not taken in the winter and spring. Probably the breeding season extends from spring to fall. Table 50 shows that naked gobies were most commonly caught in the fall and early winter.

JUGULARES

Uranoscopidae. Stargazers

Astroscopus y-graecum (Cuvier and Valenciennes). Southern Stargazer

Six specimens of this stargazer were taken. Two were caught in trawls in Aransas Bay, 3 were caught in trawls in the Gulf and 1 was caught in beach seines in the Gulf. The fish were caught in both winter and summer. The temperature at which the stargazer was caught varied from 11.1° to 22.4° C. The salinity varied from 17.7 to 35.5. Four fish ranged from 39 to 78 mm. in length. One was 155 mm. long and the other was 232 mm. long.

The stargazer has two electrical organs back of the eyes. Breder (1929) says it is not known whether the stargazer uses its electric power to stun prey or for defense alone. It was found that the largest specimen caught, 232 mm. long, delivered eight perceptible shocks. The electrical shocks could not be felt except when the hands were wet with sea water. Each shock was accompanied by spasmodic opening or gaping of the mouth. This indicates that the shocking power is used in food getting, but it does not preclude the possibility that the electric shock is used in repelling enemies.

Ophidiidae. Cusk Eels

Lepophidum brevibarbe (Cuvier). Short-beard Cusk Eel

Two of these cusk eels were taken at the Whistling Buoy, Trawl Station 9, 5¼ miles SSE of Aransas Pass in the Gulf of Mexico. They were taken January 12, and March 22, 1942, respectively. The water temperatures were 13.7° and 16.9° C. and the salinities were 33.0 to 33.9, respectively. The lengths of the eels were 203 and 129 mm.

Rissola marginata (De Kay). Slippery Dick

One example of this cusk eel was taken at the Whistling Buoy station on January 12, 1942. It was 206 mm. long. The temperature was 13.7° C. and the salinity 33.0.

Otophidium welshi Nichols and Breder. Cusk Eel

Two of these cusk eels were taken at the Whistling Buoy station on March 14 and March 22, 1942, respectively. Their lengths were 216 and 202 mm., respectively. The temperatures were 17.1° and 16.9° C. and the salinities were 35.2 and 35.9 parts per thousand.

Batrachoididae. Toadfishes and Midshipmen

Opsanus beta Goode and Bean. Oyster Dog

This toadfish lives in the shallows near oyster reefs and is more common than the numbers caught indicate. Three fish were caught in Aransas Bay and 2 in Copano Bay. Four fish were caught in October, 1941 and 1 was caught in March, 1942. Three fish were caught in trawls and 2 were taken in minnow seines. The size range of the fish was from 119 to 170 mm. in length. The temperature varied from 15.9° to 28.0° C. and the salinity varied from 11.6 to 19.5 per mille.

Opsanus sp. Oyster Dog

This is an undescribed toadfish referable presumably to the genus *Opsanus*. Five specimens were caught in Copano Bay, 3 in a minnow seine and 2 in a trawl, in the months of May and June, 1942. The size range of the fish were from 18 to 143 mm. in length. The temperatures at the 2 hauls were 24.5° and 31.0° C. and the salinities were 18.4 and 18.5 per mille.

Nautopaedium porosissimum (Cuvier and Valenciennes.) Midshipman

Eight midshipmen were caught in 4 trawl hauls. Two were caught in Copano Bay in 1 haul in April, 1941. The six other fish were taken in 3 hauls in the months of July, October and November, 1941 in Aransas Bay. The temperature varied from 15.9° to 22.0° C. and the salinity ranged from 10.3 to 35.8 per thousand. The length of the fish ranged from 76 to 154 mm.

XENOPTERYGII

Gobiesocidae. Clingfishes

Gobiesox strumosus Cope. Clingfish

This little fish is not uncommon on oyster reefs and shell banks, but it strays so little from this environment that men who have been fishermen, but not oystermen, all their lives have never seen it.

A specimen 73 mm. long was caught at Trawl Station 2 in Copano Bay, February 19, 1942. The temperature was 10.6 and the salinity was 13.6.

PLECTOGNATHI

Balistidae. Triggerfishes

Balistes capriscus Gmelin. Triggerfish

One specimen, 59 mm. long, was taken in a trawl in the Gulf 2 miles SSE of Aransas Pass on September 13, 1941. The temperature was 29.5° C. and the salinity was 36.5.

Ostraciidae. Trunkfishes

Lactophrys tricornis (Linnaeus). Cowfish

Two fish were caught in trawls. One came from Trawl Station 8, two miles SSE of Aransas Pass in the Gulf on November 25, 1941 and the other was caught in Lydia Ann Channel on March 22, 1942. The temperatures were 17.6° and 18.6° C., respectively, and the salinities were both 30.6. The lengths of the fish were 210 and 237 mm., respectively.

Tetraodontidae. Puffers

Sphoeroides marmoratus (Ranzani). Swellfish, Rabbitfish

One hundred and twenty-four puffers were caught. Twenty were caught in Copano Bay, 88 in Aransas Bay and 16 in the Gulf of Mexico. Thirty-nine fish were taken in minnow seines and 85 were caught in trawls. Table 60 shows that this puffer was most commonly caught in the late fall and early winter and during the spring. The increased abundance of this puffer in Aransas Bay and the Gulf in October and November may be the result of a general migration to deeper water with the onset of cool weather. The temperatures at which the fish was caught ranged from 8.1° to 30.1° C.

Table 4 shows that this puffer was practically absent at salinities below 10.0 and was not often caught below a salinity of 15.0. The salinity range at which the fish was caught was from 4.4 to 35.8 per thousand. The smallest fish were taken between salinities of 15.0 and 25.0 parts per thousand.

The size range of the puffers caught was from 13 to 131 mm. in length. The 13 mm. fish were taken in the bays during the months of April and May and following that the fish were larger. The smallest fish seen had the power to inflate and they resembled white peas floating in the water.

Diodontidae. Porcupinefishes

Chilomycterus schoepfi (Walbaum). Spiny Boxfish

Twenty-six of these swellfish were caught. All of them were taken in Aransas Bay. Four fish were caught in trammel nets and 22 were caught in trawls. All of the fish except 8 were taken in the vicinity of an oyster reef in lower Aransas Bay. They ranged from 104 to 273 mm. in total length. The fish were caught in the months of July, August, November and December, 1941 and February, March and October, 1942. The temperatures where they were taken varied from 13.8° to 28.0° C. and the salinities varied from 21.2 to 37.2 per thousand. Table 4 shows that few fish were caught where the salinity was below 25.0 parts per thousand. This species evidently prefers waters of high salinities, and probably was not found in the Gulf because of the absence of reef animals on which it feeds, such as oysters and barnacles, in the areas where the trawl hauls were made.

PEDICULATI

Ogcocephalidae. Batfishes

Ogcocephalus nasutus (Cuvier and Valenciennes). Batfish

Twelve batfish that corresponded in character with the description of *C. nasutus*, as treated by Longley and Hildebrand (1941), were caught at the two trawl stations in the Gulf during the months of September and November, 1941 and March, April and May, 1942. The temperature of the water varied from 17.1° to 29.5° C. and the salinity ranged from 26.7 to 36.6 per mille. The fish were from 81 to 187 mm. in length.

Ogcocephalus vespertilio (Linnaeus). Batfish

Five batfish of this species were taken at Trawl Station 8 two miles SSE of Aransas Pass in the Gulf of Mexico on August 30, 1941. The temperature was 30.0° C. and the salinity was 36.7. The fish ranged from 125 to 210 mm. in length.

HETEROSOMATA. Flounders and Flatfishes

Bothidae

Syacium gunteri Ginsburg

One hundred and ninety-two specimens of this little fish were taken in trawls at the 2 Gulf stations in the months of July, August, September, and November, 1941, and March, April and May, 1942. The water temperatures varied from 16.9° to 30.0° C. and the salinity varied from 30.7 to 36.7 per mille. The size lengths of the fish ranged from 91 to 146 mm.

Citharichthys macrops Dresel

Two fish were caught in a trawl in the Gulf two miles SSE of Aransas Pass on November 25, 1941 and March 13, 1942. The temperatures were 17.6° and 15.4° C. The salinities were 30.6 and 35.2 per thousand. The fish were 140 and 142 mm. in length.

Citharichthys spilopterus Günther

Seventy-five fish were caught. Five fish were caught in minnow seines and the remainder were caught in trawls. Twenty-two fish were taken in Copano Bay, 40 in Aransas Bay and 13 in the Gulf of Mexico. This fish as taken at all seasons. Table 52 shows the monthly catch. The temperature at which the fish was caught ranged from 14.2° to 30.5° C. No fish were caught in Copano Bay between October and April. None was caught in Aransas Bay from January to March and none was caught in the Gulf in January. It was not found in Louisiana in Barataria Bay in December and January (Gunter, 1938c). Apparently, this species goes into deeper water as cold weather approaches.

The lowest salinity at which this flatfish was caught was 2.5 and the highest was 36.7. Table 4 shows that it was taken at all salinities but was caught in greatest numbers where the salinity was above 15.0 per thousand. Fifty-six fish taken between salinities of 2.5 and 24.9 ranged from 21 to 140 mm. in length, while 19 fish taken at salinities from 25.0 to 36.7 ranged from 76 to 135 mm. in length.

The smallest fish, from 21 to 55 mm. in length, were taken in April, 1942 in Aransas Bay. In May all fish taken were over 55 mm. long and they were larger in all succeeding months. The size range of all specimens was from 21 to 140 mm. in total length.

Etropus crossotus Jordan and Gilbert. Fringed Flounder

Two hundred and ten fish were caught. One was taken in a minnow seine and the remainder were caught in trawls. One fish was caught in Copano Bay, 113 were caught in Aransas Bay and 96 were caught in the Gulf of Mexico. Table 53 gives the monthly catches. No fish were caught in the bays in January and they were scarce in February and March. The time of greatest abundance was from October to January. The temperature range at which the fish was caught was from 13.7° to 30.5° C.

The salinity range at which the species was caught was from 4.4 to 36.7. Table 4 shows that only 1 fish out of 210 was taken at a salinity below 15.0. Evidently the fish does not like brackish waters. Some relation was found between the salinity and the size of specimens caught. The smallest fish were taken in water between 25.0 to 30.0 per mille salt. There were only two fish out of 141 measured that were greater than 131 mm. long below a salinity of 30.0. The longest was 138 mm. in length. Above a salinity of 30.0 there were 10 fish out of 68 measured that were greater than 131 mm. long. The largest was 156 mm. long.

The size range of the fish was from 64 to 156 mm. in length. Total length-frequency curves yielded no information on the life history and they are not presented.

Pleuronectidae. Flounders

Ancylopsetta quadrocellata Gill. Ocellated Flounder

Ten fish were caught, seven in Aransas Bay and 3 in the Gulf of Mexico in the months of July, August, September, March, April and May. All fish were taken in trawls. The temperature range was 15.4° to 30.0° C. and the salinity range was 22.8 to 36.7. Seven of the fish were taken where the salinity was above 30.0. The size of the fish ranged from 64 to 187 mm. in length. Three fish from 64 to 89 mm. in length were taken in March and April. All other fish were above 121 mm. in length.

Paralichthys albigutta Jordan and Gilbert. Gulf Flounder

Twelve Gulf flounders were caught. Nine were taken in Aransas Bay and 3 were caught in the Gulf. Seven fish were caught in trawls, 4 were caught in trammel nets and 1 in a minnow seine. These flounders were caught in the months of March,

June, August and October, 1942. The size of the fish ranged from 144 to 345 mm. The temperature range where they were caught was from 15.4° to 30.3° C. The salinity range was from 9.6 to 35.2 per mille. Ten fish were taken at salinities above 25.0.

Paralichthys lethostigma Jordan and Gilbert. Southern Flounder

Two hundred and forty-one southern flounders were caught. Five fish were caught in the Gulf, 81 were caught in Aransas Bay and 155 were taken in Copano Bay. Sixteen fish were taken in minnow seines, 25 were taken in trammel nets and 200 were taken in trawls. Table 54 gives the monthly catch. The fish was taken at all seasons in the bays, but was found in the Gulf only in March and April. The temperatures where it was caught varied from 9.9° to 30.5° C.

The salinity range at which the species was caught was from 2.0 to 36.2. Table 4 shows that this flounder was caught in numbers at all salinities below 25.0 parts per thousand, but above that few fish were caught. Apparently this fish, at least in the sizes caught, prefers bay and less salty waters.

During the fiscal years 1936–37 to 1941–42, the Texas Coast has produced commercially an annual average of 117,882 pounds of flounders (Ann. Repts. 1936–37 to 1941–42, Game, Fish and Oyster Comm.). Of this amount 102,369 pounds came from the bays and 15,513 pounds came from the Gulf.

Flounders with developing roe were taken in October, 1942. Young fish from 17 to 40 mm. in length were caught in Aransas Bay in the months of December, February, March and April. The salinity at these stations varied from 19.6 to 30.0 per mille and the temperature varied from 14.5° to 21.6° C. In May the youngest fish were 80 mm. long and the lower size limit increased rapidly during the summer. The size of flounders caught ranged from 17 to 490 mm. in length.

This fish is the only commercial fish taken in any numbers by shrimp trawlers. During the fall small flounders, many of them a little under the legal limit of 12 inches, are taken in shrimp trawls in some numbers. They are probably about one year old.

Sixteen flounders measuring from 24 to 49 cm. in length were examined for stomach contents. Eight fish were empty. Seven had eaten fish. In 3 instances the fish were not identified. Mullet, anchovies *(A. mitchilli diaphana)*, a pinfish *(L. rhomboides)* and a mojarra were eaten the other times. In 3 instances the flounders had eaten peneid shrimp *(P. setiferus* and *P. aztecus)* and a stone crab.

Soleidae

Achirus fasciatus Lacépède. American Broad Sole or Hogchoker

Ninety-eight fish were caught. Forty-four fish were taken in the bays and 54 were taken in the Gulf. Three soles were caught in trammel nets and 95 were caught in trawls. Table 55 shows the monthly catches. The fish was caught in all seasons at temperatures varying from 14.4° to 30.5° C. No soles of this species were taken in the bays in January and February and none was taken in the Gulf except in

November and January. It appears that this sole goes to deeper water during cold weather.

The salinity where *A. fasciatus* was caught varied from 3.7 to 33.7 per thousand. Table 4 shows that few fish were caught below a salinity of 10.0, but they were more common above that salinity and were most abundant in salinities above 30.0.

The smallest fish caught was 51 mm. long and the largest was 140 mm. long. The smallest fish were caught in November and December.

Achirus lineatus (Linnaeus). Lined Sole

One hundred and twenty-five soles were caught. Two fish were taken in minnow seines. Twenty-four fish were taken in Copano Bay, 76 were taken in Aransas Bay and 25 were taken in the Gulf. Table 56 gives the monthly catches. Fish were taken at all seasons both in the bays and the Gulf. The temperatures at the stations varied from 10.6° to 30.0° C.

The salinity at the stations varied from 2.5 to 36.2 per thousand. Table 9 shows that the catch of fish below a salinity of 10.0 was small. Seventy fish taken below salinities of 25.0 were from 27 to 113 mm. long, while 55 fish taken above that salinity were from 63 to 128 mm. long.

The smallest fish caught was 27 mm. long and the largest was 128 mm. long. The smallest fish were found in July, 1941 in Aransas Bay. The salinity was 20.2.

Symphurus plagiusa (Linnaeus). Tonguefish

Two hundred and fifty-six fish were caught. Eight fish were taken in minnow seines. The remainder were taken in trawls. Twelve fish were caught in Aransas Bay and 244 were caught in the Gulf. Table 57 gives the monthly catches. The tonguefish was caught only in the months of November, December, January and April in Aransas Bay, but it was caught at all seasons in the Gulf of Mexico. It was least abundant in summer. The temperature range at the stations was 13.7° to 29.5° C.

The salinity range where the tonguefish was caught was from 17.1 to 36.7 per thousand. Table 4 shows that 90.6 per cent of the fish were caught where the salinity was above 30.0 per thousand. The tonguefish definitely prefers waters of high salinity. Twenty-four fish taken in water with a salinity less than 30.0 ranged from 34 to 186 mm. in length and 12 of them were less than 105 mm. long. Only one fish was greater than 150 mm. long. One hundred and sixty-six fish taken at salinities above 30.0 ranged from 116 to 173 mm. long and 28 of them were longer than 150 mm.

The fish caught ranged from 34 to 173 mm. in length. Fish below 40 mm. in length were taken in the months of November, December and January in Aransas Bay. Two fish 133 and 134 mm. long with ripe eggs, were taken in the gulf of Mexico at the Whistling Buoy 5¼ miles SSE of Aransas Pass on April 22, 1942. The temperature was 20.5° C. and the salinity was 30.7.

VI. Relative Numbers and Species Mass of Texas Coastal Fishes

Knowledge of the relative numbers of fishes and other animals of the shallow Gulf waters is necessary for an understanding of the ecology of this region and a comprehensive view of the life of this area cannot be had without it. Gunter (1936, 1938a, and 1941c) supplied certain information on this subject concerning fishes only and based chiefly on data taken by trawling on the Louisiana Coast.

One hundred and nineteen species of fishes were caught. The total number of specimens was 78,265. Table 58 gives the total number of fishes caught in the bays and the Gulf with each kind of gear. The average numbers of fishes caught in the two places with the different gear are also shown. Seventy-two species made up less than 1.5 per cent of the catch. They are listed in table 59 in graded series according to the number of times they were caught. Four fresh water species that stray only occasionally into brackish waters are not considered. Data on the catch of each species are given in the text. Examination of these data will give some idea of whether the fish is purely marine or a bay species and other information.

Table 60 gives all species that were taken over 100 times and the number of times they were caught. The numbers of times they were caught in the various gear both in the bays and Gulf have been previously stated in the text. This last factor is important for it gives some information about the sizes of the fishes and shows whether they were caught in shallow or deep water or both. This is the reason why the ways in which the fishes were caught have been carefully stated, with seemingly monotonous reiteration, throughout this paper and the reason why the tables of monthly catches show the catch for each kind of gear. Small fish were caught in shallow water by minnow seines. Large fish were caught in shallow water in trammel nets and beach seines. Both small and medium-sized fish were taken in deep water by means of trawls. No gear for catching large fish in deep water was used.

The fishes taken in Copano and Aransas Bays are not separated in table 60. The difference between these two bays is primarily one of the salinity of the water and a few fishes taken in Aransas Bay were not caught in the less saline water of Copano Bay. The monthly catch records show the differential distribution of species in the two bays and they will not be discussed here except to say that the following species listed in table 60 were taken in Aransas Bay but were not caught in Copano Bay: *Vomer setapinnis, Chloroscombrus chrysurus, Orthopristes chrysopterus, Menticirrhus americanus, Cynoscion nothus,* and *Symphurus plagiusa.* Several other species were caught much more often in Aransas Bay than in Copano Bay, as has been shown in the previous tables.

The knowledge of total species mass is as important as the actual numbers of fishes involved. Only the relative species masses can be estimated at present. Many factors must be held in mind in making estimates of relative numbers or relative species mass. Table 60 shows that 3 species of fishes, *Micropogon undulatus, Anchoa*

mitchilli diaphana and *Menidia beryllina peninsulae* were caught almost as often as the other 117 species of fishes put together. The number of these 3 fishes caught was 36,965. The first was taken largely in trawls, the second in both trawls and minnow seines and the third almost completely in minnow seines.

The writer (Gunter, 1941c) estimated that *Anchoviella* sp., *Brevoortia patronus*, *Mugil cephalus*, and *Micropogon undulatus* had a greater species mass than any other fishes on the northern Gulf Coast. The anchovy is *Anchoa mitchilli diaphana*. It is ubiquitous in all waters of the bays and shallow Gulf and the data collected here tend to confirm the opinion stated previously *(op. cit.)* that it has a greater species mass than any other fish of shallow Gulf waters. It was found in the course of this study that there are 2 menhadens in Texas, a Gulf species, *Brevoortia tyrannus* and a bay species, here called *Brevoortia* sp. This fish is a pelagic plankton feeder and the gear used was not suitable for catching it and neither was the gear suited for catching the mullet, *Mugil cephalus*, which was observed in enormous numbers. They jumped over or went through trammel nets and were too active to be taken in minnow seines except when very small. With the menhaden and the mullet direct observation rather than the numbers caught governed the estimates of their relative abundance. These two fish and the croaker, *Micropogon undulatus*, probably rank next to the bay anchovy in species mass on this coast. The silverside, *Menidia beryllina peninsulae*, and the cyprinodontid, *Cyprinodon variegatus variegatus*, rank high in relative species mass and they would have higher rank, except that they are confined to a narrow strip next to shore. The catfish, *Galeichthys felis*, and the sand trout, *Cynoscion arenarius*, are also very abundant species. The three chief commercial species the redfish, *Sciaenops ocellata*, the speckled trout, *Cynoscion nebulosus*, and the black drum, *Pogonias cromis*, are probably close to the catfish and sand trout in species mass.

Three of the four fishes estimated as having the greatest species mass feed near the base of the food pyramid. The anchovy and menhaden are plankton feeders and the mullet feeds largely on diatoms and other algae sucked up from the surface of the bottom. The croaker is an omnivorous bottom feeder.

The estimates of relative species mass of the fishes given here are based on general impressions and observations, bolstered to some extent by data, and are admittedly more subjective than is desirable. It is quite certain, however, that irrespective of their rank in species mass, the species discussed are the most numerous fishes in Texas coastal waters. The estimates of the four most abundant fishes is the same as given by the writer (Gunter, 1941c) and they have not been changed by additional data. The data of this paper have instead given new information chiefly on the fishes of secondary importance so far as numbers and species mass are concerned.

The common commercial shrimp *Penaeus setiferus* and the crab, *Callinectes sapidus*, are extremely abundant in these waters. It is possible that the shrimp exceeds all other macroscopic animals in species mass.

Table 60 shows that the fishes of the family Sciaenidae were caught in greatest numbers. The same thing was found with respect to this family in the trawl catches in Louisiana (Gunter, 1938a). So far as numbers are concerned the Sciaenidae is the predominant family of fishes of the coastal waters of the northern Gulf of

Mexico. This family was followed by the Engraulidae, Atherinidae and Cyprinodontidae in numbers caught in Texas.

Gunter (1938a, Table 1, p. 79) gave the numbers of fishes that were taken in 422 trawl hauls in Louisiana during the years 1931, 1932 and 1933. Table 61 shows the order of abundance of the 26 fishes most often taken in trawls in Louisiana compared with fishes taken in trawls in Texas for both bay and Gulf waters. In Louisiana hauls were of one hour's duration and they were made with a trawl 60 feet wide. In Texas the hauls were only 30 minutes in duration and they were made with a trawl 30 feet wide. In Louisiana 422 hauls were made and over 144,000 fishes were caught, while in Texas 109 hauls were made and 36,484 fishes were caught. Therefore, the actual figures are not comparable. For these reasons only the order of the abundance of the fishes is given. In compiling the table the terminology of Gunter, *(op. cit.)*, has been changed to correspond with that used in this paper and the data erroneously showing that the cutlass fish, *Trichiurus lepturus*, was taken more often in the bay than in Gulf waters in Louisiana was rectified. The table is self-explanatory and it will not be discussed in detail. In spite of the fact that certain fishes were on the Texas list that were not on the Louisiana list and vice versa and that the order of abundance was different in several instances, the general correspondence of the order of abundance of fishes taken in the two places, several years apart, is high. In the bay waters in both places the croaker was most abundant, followed by the anchovy. The two catfishes seemed to be relatively more abundant in Texas and *Brevoortia* sp. was relatively less abundant. The star drum, *Stellifer lanceolatus*, was relatively less abundant in Texas bay waters. There was greater difference between Gulf catches. The white trout, *Cynoscion nothus*, exceeded the croaker in the Texas catch and the threadfin, *Polydactylus octonemus*, and the catfish, *Galeichthys felis*, were relatively more abundant. The anchovies were much less common in the outside catches. The greatest noticeable difference was the fact that the sciaenid, *Stellifer lanceolatus*, found so abundantly in Louisiana was not numerous in Texas waters. The ratio of this fish to the croaker in Louisiana was 1 to 6.1, while in Texas it was 1 to 39.3. Another sciaenid, *Larimus fasciatus*, was caught 208 times among 144,000 fishes in Louisiana, but only 4 were taken among 36,484 fishes in Texas. In Louisiana the butterfish, *Poronotus triacanthus*, and the cutlass fish, *Trichiurus lepturus*, were often caught, but they were much less common in Texas waters. The stingaree, *Dasyatis sabina*, was much more common in Texas Gulf hauls than in Louisiana. The gizzard shad, *Dorosoma cepedianum*, the rough scad, *Trachurus lathami*, the pinfish, *Lagodon rhomboides*, the pigfish, *Orthopristes chrysopterus*, and the two mullets, *Mugil cephalus* and *M. curema*, were taken in trawls in Texas, but not in Louisiana.

Table 62 compares the families of fishes and their abundance taken in trawls in Louisiana with those taken in Texas (Gunter, 1938a). The predominance of the sciaenids was less in Texas waters. The sciaenids made up 47.6 per cent of the catch in Texas and 62.6 per cent of the catch in Louisiana. In Texas four times as many hauls were made in the bays as in the Gulf. Most sciaenids were caught in the bays and if bay and Gulf hauls had been approximately equal, as they were

in Louisiana, the predominance of the Sciaenidae would have been still less. Likewise the relative number of anchovies (engraulids) would have been less and the Otolithidae more, so that the order of abundance of the first four families would have probably been the same as in Louisiana. The relative abundance of several families was little changed. For instance, the percentages of Clupeidae, Heterosomata, Carangidae, Triglidae and Tetraodontidae were not greatly different in the two states. On the other hand, the relative abundances of Trichiuridae, Stromateidae, and Ephippidae were much less in Texas waters.

VII. General Distribution of Texas Coastal Fishes

The environment of the fishes studied in this work may be classified or divided into several parts. A general description of the area was given in the introduction. The first large division is the Gulf and the bay or estuarine region (the inland salt waters). Aside from differences in salinity which were discussed in the introduction, there are other differences between these two areas. The Gulf waters are deeper and are not subject to such extreme changes in temperature. The muds of the Gulf bottom are harder and firmer than those of the bays, which in some places are ooze. The shallows of the Gulf beach are monotonous stretches of sand without macroscopic plant life or cover, while the shallows in the bays are covered in places with grass and algal growths.

The bay area may be divided into three parts, deep or offshore waters, oyster reefs, which were not studied, and the shallows or inshore waters. The offshore waters range from 4 to 12 feet in depth and are typically mud bottom without vegetation. The inshore shallows are known in common parlance as flats. These flats line the shores of all bays and may extend from a few yards to over a quarter of a mile in width. They are usually around 2 feet in depth and drop off rather sharply at the outer edge to deeper water. Since the tidal exchange is small in this area the flats are rarely uncovered, even in part. Rarely during heavy northers the flats may become partly dry. The bottoms of the flats are not alike. In some places they are covered with growths of algae and higher plants. In others they are bare sand, ooze-like mud covered with decaying vegetation, or hard clay-like mud pitted in such a way that the bottom resembles that of ponds waded and trampled by livestock. In other places oyster shells in various states of erosion form the bottoms. Over most of the flats there is usually cover of some kind for small fishes and crustacea.

The most numerous fishes on the bay flats, as shown by minnow seine catches, table 63, are the silverside, *Menidia beryllina peninsulae,* the cyprinodontid, *Cyprinodon v. variegatus,* the anchovy, *Anchoa mitchilli diaphana,* the mullet, *Mugil cephalus* and the cyprinodontid, *Fundulus similis.* Here also are found, especially among vegetation, vast numbers of the shrimp, *Palaemonetes vulgaris.* The fishes, *Brevoortia* sp., *Membras vagrans vagrans, Lucania parva, Fundulus grandis, Mugil curema, Lagodon rhomboides, Micropogon undulatus* and *Gobiosoma bosc* are common, but much less numerous on the flats. Pipefishes and small gobies are probably more abundant than the catches indicate for they live in vegetation and easily elude the seines. The Gulf sardine, *Harengula macropthalma,* is taken only sporadically in the lower bay.

The two silversides, the cyprinodontids and the palaemonid shrimp are never taken anywhere but on the comparatively narrow strip of flats next to shore. They do not inhabit deeper waters, where the salinity and temperature are suitable, and of the 3,460 square miles of Texas inland salt waters probably 400 square miles or less are occupied by them. In all probability a chief requirement for these animals

is ample cover and protection, which is not obtainable in the deep waters, hence their absence in the open bays. The reactions of hiding and cover seeking are commonly observed when the small shore fishes are disturbed. The palaemonid shrimp, and the cyprinodontids, with the rare exception of *Fundulus similis*, are not found on the Gulf beach. The silverside, *M. b. peninsulae*, is uncommon there and these animals may be said to be typical of the bay flats. The gobies and pipefishes are occasionally taken in deep water in the bays, but they are not taken in the Gulf, and they too may be said to be typical inhabitants of the bay flats.

Mullet are largely shore and shallow water fishes, but they are larger than the cyprinodontids and silversides and are occasionally found in deep waters, although the young probably do not normally leave the flats. The young of many species of fishes in the bay waters, as well as young blue crabs and young peneid shrimp, largely remain in the shallows. At times young crabs, young peneid shrimp, small croakers, young menhaden and the anchovy, *Anchoa mitchilli diaphana*, in all sizes, are found in the shallows outnumbering the purely shallow water species. *A. mitchilli diaphana*, *Lagodon rhombodies* and *Brevoortia* sp. were the only three species taken in about equal abundance in both deep and shallow waters. The smaller fishes of the last two species were taken in shallow water and the larger fishes in deeper water.

Large fishes and crabs also visit the flats to feed and practically all commercial fishing is done here with trammel and gill nets, trotlines, and pole and line. Floundering is also done on the flats by use of gigs.

As is shown by table 64, the bottom areas of deep water of the bays are inhabited by large numbers of croakers, *Micropogon undulatus*, anchovies, *Anchoa mitchilli diaphana*, catfish, *Galeichthys felis*, and sand trout, *Cynoscion arenarius*. Also common at times in this environment are *Bagre marina*, *Leiostomus xanthurus*, *Brevoortia* sp., *Polydactylus octonemus*, *Dorosoma cepedianum*, *Lagodon rhomboides*, *Signalosa mexicana*, and *Orthopristes chrysopterus*. Some of these fishes are present more or less seasonally. *Bagre marina* and *Polydactylus octonemus* are totally lacking in the winter. It is clear that the distributions of fishes in deeper waters and the flats of the bays are quite different. The peneid shrimp, *Penaeus setiferus*, is also enormously abundant in the deeper waters of the bays. The blue crab, *Callinectes sapidus*, is common.

The differences between kinds of fishes living in the shallow surf of the Gulf beach and the offshore bottoms are also shown by tables 63 and 64. The sardine, *Harengula macropthalma*, the anchovies, *A. m. diaphana*, and *A. hepsetus*, the threadfin, *Polydactylus octonemus*, and small pompano, *Trachinotus carolinus*, are the chief fishes of the shallow Gulf beach. Small mullet and the rough silverside, *Membras vagrans vagrans*, are also common at times. In offshore waters the chief bottom fishes are the sand trout, *Cynoscion nothus*, the croaker, *Micropogon undulatus*, the threadfin, *P. octonemus*, the catfish, *G. felis*, the moonfish, *Vomer setapinnis*, the star drum, *Stellifer lanceolatus*, two flatfishes, *Syacium gunteri* and *Symphurus plagiusa* and two sciaenids, *Leiostomus xanthurus* and *Menticirrhus americanus*. The shrimp, *Penaeus setiferus*, and the crabs, *Callinectes sapidus* and *Callinectes danae* are also very common.

The mullet, *Mugil cephalus*, the speckled trout, *Cynoscion nebulosus*, and the redfish, *Sciaenops ocellata*, were the larger fishes taken most commonly on the bay flats, as shown by table 65. The most common larger fishes on the Gulf beach were, the spot, *Leiostomus xanthurus*, the mullet, *M. cephalus* and the stingaree, *Dasyatis sabina*.

Table 64 shows that in trawls in the bays the order of abundance of the families was the Sciaenidae, Engraulidae, Ariidae, Otolithidae, Clupeidae, and Polynemidae. In the trawls in the Gulf, the order was Otolithidae, Sciaenidae, Polynemidae, Ariidae, Heterosomata and Carangidae, with the Engraulidae far down the line. In minnow seines in the bays, table 63, the order of abundance of the families was: Atherinidae, Cyprinodontes, Engraulidae, Mugilidae, and Clupeidae, while on the Gulf beach the order was Engraulidae, Clupediae, Polynemidae, Mugilidae and Carangidae. In the large nets in the bay shallows, table 65, the order of abundance of the families was: Sciaenidae, Clupeidae, Mugilidae, Otolithidae, and Ariidae, while in Gulf shallows it was Sciaenidae, Mugilidae and Carangidae.

No study was made of the fishes and crustacea and other animals living on oyster reefs and this ecological niche has not had close study anywhere in this country. The fishes that live on oyster reefs are not active swimmers and they are equipped for living in and under oyster shells. They attach their eggs to oyster shells so the developing eggs do not drift away from the reef. The chief oyster reef fishes are *Opsanus* spp., *Gobiesox strumosus* and several blennies.

VIII. Temperature Relations and Seasonal Cycles

Collier (MS and Ann. Rep., Game, Fish and Oyster Comm., 1937–38) has shown the temperature cycle of Texas coastal waters. June, July and August are warm months, with the temperatures more or less static. September, October and November are transitional with temperatures declining to the cold months of December, January and February. January is usually the coldest month. March, April and May are transitional months with rising temperatures to the warm months. Any given year may vary somewhat from this simple temperature cycle. During the time this study was made September was a warm month.

Certain seasonal changes were noted in the fish population coinciding with seasonal temperature changes. It is difficult to say with certainty that the migration or changing seasonal status of any one fish is directly due to temperature change. For instance, a fish may follow a food organism about, which in turn is controlled by temperature. Nevertheless, the overall seasonal changes in the fish population doubtless are caused by temperature change, whether it is a direct or indirect cause.

Most marine animals in the temperate zones have definite breeding seasons. The spring, especially the month of April, was the time when the gonads of most fishes and crustacea burgeoned. Spring in the water was as evident as it was on land. In the air at the same time the male gulls became for once very gallant and called the females when food was found. Although most fishes spawned in the spring and summer, several of them spawned in the fall and winter. The fact that different fishes and other aquatic animals spawn at different times of the year has long been known. Ortmann (1907) said that the species of crawfish fall into two groups, 1. the cold water group which breeds more or less throughout the year and, 2. the warm water group which breeds in the fall and spawns in the spring. Orton (1920) pointed out that most marine animals fall into two general groups, those that spawn when the temperature reaches or approaches the maximum and those that spawn when the temperature reaches or approaches the minimum. The spawning times of several fishes have been recorded in this paper. On the basis of the time of spawning table 66 was prepared. The time of appearance of the young was used in determining the general spawning period in cases where ripening gonads were not noted. All doubtful species were excluded. Over six times as many fishes spawned in the spring and summer as spawned in the fall and winter. Most of the fishes spawning in the fall and winter were of temperate and subtropical distribution, while the warm month spawners included a majority of species that are subtropical and tropical in distribution. Many have not been recorded north of the Gulf of Mexico. This is more or less to be expected for the cold "northers" that strike the Texas Coast in winter give the region more of a temperate climate character than the same latitudes have farther east and fishes are sometimes killed in large numbers by the sharp cold spells. The young of tropical species would not survive the cold as well as the young of more temperate species. Storey (1937) has shown that fishes of tropical distribution in Florida are more often killed by cold spells than are the species of temperate distribution.

Table 67 shows that the summer and winter were the seasons of greatest abundance of small fishes in the shallows of both Copano and Aransas Bays. On the Gulf beach the summer and fall were the seasons of greatest abundance, with the spring low and the winter decidedly lower. The fall and spring were the seasons of least abundance in the bays. This picture compared much better with the net catch for large fish in the same environment than it did with the trawl catches. The table shows that the catch of large fish in the shallows was decidedly low in the spring in both bays and that it was low both in the winter and spring on the Gulf beach. The trawl catches were different from the shoal water catches. There was little seasonal variation in abundance in the trawl catches in the Gulf. In the bays the events were different. The season of greatest abundance was the summer. During the fall the abundance dropped and it reached a low point in the winter. It became high again during the spring. In making up the tables June, July and August were classed as summer months, September, October and November as fall months, December, January and February as winter months and March, April and May as spring months.

Table 68 shows the average catch in minnow seines by months. Fishes were very abundant in July, but a decline in numbers first showed in August, 1941 in Copano Bay and reached a low point in September. Following that there was a rise in numbers to a peak in January followed by a decline in March. In August the fishes were very abundant again. The chief fishes caught in the summer were *Anchoa mitchilli diaphana, Menidia beryllina peninsulae* and *Cyprinodon variegatus variegatus,* with *Membrans vagrans vagrans* of lesser importance, and the variations in abundance of these three fishes accounted for most of change in seasonal changes in abundance in Copano Bay. *A. m. diaphana* was caught in greatest numbers in the summer and fall, although its appearance was more sporadic than *M. b. peninsulae,* which exceeded it in numbers in June, August and September. The large catch in June was due to *A. m. diaphana.* In December and January *C. v. variegatus* was the most numerous fish and the large catch in the latter month was due to this fish. It was the most abundant fish taken during the winter months. Small *Brevoortia* sp. appeared in February and in April this species exceeded all other fish in numbers caught. *A. m. diaphana* was the most abundant fish taken in the spring, while *C. v. variegatus* disappeared in April and May and *M. b. peninsulae* was not numerous. In June and August, 1942 those two fishes were abundant and *A. m. diaphana* had declined. *M. v. vagrans* disappeared from the bays in the winter time. Small specimens of *Micropogon undulatus, Mugil cephalus* and *Brevoortia* sp. all appeared in the catches in February. The first two came from the Gulf beach, while the latter was spawned in Copano Bay. The monthly catch of each species as well as the size changes throughout the year have been shown previously.

Table 68 shows that the decline of the catch in minnow seines in Aransas Bay was more gradual than in Copano Bay and the low point was not reached until December. The month of greatest abundance in the winter was February rather than January and the lowest spring month was April rather than March in contrast to Copano Bay. In brief, the abundance changes in Aransas Bay minnow seine hauls seemed to lag about a month behind those of Copano Bay. *M. b. peninsulae* and *C. v. variegatus* were the most numerous fishes, in all seasons except the winter,

when *Mugil cephalus* was taken in large numbers in January. *C. v. variegatus* was caught in greater numbers than other species in December and February, corresponding to the winter increase of this species in December and January in Copano Bay. *A. m. diaphana* was not numerous in the winter but it was the most abundant fish in the April catch, corresponding to the large spring increase of the species in Copano Bay. It was much less numerous in March and was exceeded in numbers caught by *M. b. peninsulae* in May. It was exceeded by that fish, *Mugil curema* and *Fundulus similis* in the summer. *Membras vagrans vagrans* was taken in numbers only in October, doubtless as it was leaving the bay area. Only 2 specimens were taken in November and the fish disappeared from Aransas Bay during December, January and February. Small *Micropogon undulatus* appeared in large numbers in February, as they did in smaller numbers in Copano Bay at the same time. *Brevoortia* sp. did not come from Copano into Aransas Bay until April when it was numerous, but for that month only.

Table 68 shows that the catch of small fishes on the Gulf beach declined sharply in the winter. In 1942 the decline came earlier, being in October and November. *A. m. diaphana* followed by *M. cephalus* and *Polydactylus octonemus* were the most numerous fishes on the Gulf beach in the spring. In the summer *P. octonemus*, followed by *Harengula macropthalma, Trachinotus carolinus* and *Anchoa hepsetus* were the most abundant fishes. In the fall *A. m. diaphana* followed by *H. macropthalma* and *T. carolinus* were the most abundant fishes. In the winter *M. cephalus* was very abundant and it was followed by *A. m. diaphana* in much less numbers.

Table 69 shows that there was a gradual decrease in the numbers of fishes in the trawl catches in both bays during the fall with a low point in December in Copano Bay and a low point in January in Aransas Bay. The catches increased again through the spring. In Copano Bay in the spring the croaker, *Micropogon undulatus*, was overwhelmingly predominant in numbers, followed by *Galeichthys felis, Brevoortia* sp., and *A. m. diaphana*. In the summer *M. undalatus* was still overwhelmingly predominant followed by *A. m. diaphana, Cynoscion arenarius, Dorosoma cepedianum* and *Galeichthys felis*. In the fall *A. m. diaphana* outnumbered other fishes slightly and it was followed in order by *M. undulatus, Cynoscion arenarius, Brevoortia* sp., *Bagre marina* and *Galeichthys felis*. In the winter *A. m. diaphana* was taken about twice as often as *M. undulatus* and no other fish was at all numerous.

In Aransas Bay in the spring *M. undulatus* was overwhelmingly predominant, followed by *A. m. diaphana, G. felis, L. xanthurus* and *Cynoscion arenarius* in that order. In the summer the croaker was still greatly predominant followed by *P. octonemus, C. arenarius, L. xanthurus* and *G. felis*. In the fall *C. arenarius* slightly outnumbered *M. undulatus* which was followed by *G. felis, Bagre marina* and *A. m. diaphana*. In the winter *A. m. diaphana* was overwhelmingly predominant followed by much fewer numbers of croakers, *G. felis* and *C. arenarius*. No other fish was often caught.

In the Gulf of Mexico no one fish was so overwhelmingly numerous as was often the case in the bays and there were a greater number of species at all times of the year. In the summer the order of abundance in trawl catches was: *M. undulatus, P.*

octonemus, Vomer setapinnis, Cynoscion nothus, L. xanthurus and *Stellifer lanceolatus.* In the fall the order of abundance was *G. felis, C. nothus, C. arenarius, M. undulatus* and *P. octonemus.* In the winter it was: *L. xanthurus, M. undulatus, C. arenarius* and *C. nothus,* while in the spring it was: *C. nothus, P. octonemus, S. lanceolatus, Syacium gunteri* and *A. m. diaphana.*

Table 70 shows that the spring was a season of small catches in large nets in both bays and the Gulf and the winter was also a season of small catches on the Gulf beach. The redfish, mullet, croaker, hardhead catfish *(G. felis),* and pinfish *(Lagodon rhombodies)* were most often caught in Copano Bay in the summer. The redfish, mullet, gizzard shad and the pinfish *(Lagodon rhomboides),* were most often taken in Copano Bay in the fall. The fishes most often taken there in winter were the gizzard shad, mullet, redfish, drum and speckled trout. In the spring the most numerous fishes were the hardhead catfish, the speckled trout, the croaker and the gizzard shad.

During the summer in Aransas Bay the order of abundance of fishes in the trammel net catches were speckled trout, *G. felis, L. xanthurus,* croaker, and *Brevoortia* sp. In the fall it was redfish, croaker, mullet and speckled trout. In the winter the order of abundance was mullet, *Brevoortia* sp., speckled trout and redfish. In the spring it was *Brevoortia* sp., hardhead catfish and speckled trout.

On the Gulf beach in summer the chief fishes caught were *P. octonemus, Trachinotus carolinus* (common pompano), *Chloroscombrus chrysurus* and the stingaree, *Dasyatis sabina.* In the fall the chief fishes caught were the spot or flat croaker, *L. xanthurus,* black drum, speckled trout, *Chloroscombrus chrysurus* and the croaker. In the winter the chief fishes taken were the flat croaker and the mullet. In the spring the fishes taken in greatest numbers were the hardhead catfish and the mullet.

During the spring many fishes which are taken only in the Gulf during the winter or which are absent entirely, begin to come into the bays. Some of them go only into Aransas Bay and many that go into Copano Bay are taken there only rarely in the summer or fall. At the same time several species which do not enter the bays appear in the Gulf catches only in the summer. Many fishes which migrate largely into Gulf waters in the winter and are uncommon in the bays during the winter return in large numbers in the spring. This influx into the bays continues on through the warm months and some species are not found in the bays until late summer and fall. During the fall the redfish, *Sciaenops ocellata,* the croaker, *Micropogon undulatus,* and the mullet, *Mugil cephalus,* begin an exodus from the bays and go to the Gulf beach where they spawn in the late fall and early winter. The stingaree, *Dasyatis sabina,* the hardhead catfish, *Galeichthys felis,* and the gafftopsail catfish, *Bagre marina,* depart and the first two become more numerous in Gulf waters, while the latter disappears largely even in the Gulf. Many other fishes largely leave the bays at the same time. The rough silverside, *Membras vagrans vagrans,* left the bays in the winter. *Orthopristes chysopterus* was found only in the bays in summer, but in midwinter it was found only in the Gulf. *Lagodon rhomboides* was scarce in the bays in December and was caught in the Gulf from November to January only. The yellowtail, *Bairdiella chrysura* was taken in the Gulf from November to January only. The flat croaker, *Leiostomus*

xanthurus, was scarce in the bays in January and abundant in the Gulf only at that time. *Stellifer lanceolatus*, the star drum, which entered Copano Bay only in the fall was not found in either of the two bays in midwinter. The whiting, *Menticirrhus americanus*, was absent from the bays in January and was found more abundant in the Gulf then than at any other time. The white trout, *Cynoscion arenarius*, was scarce in the bays in the winter and most abundant in the Gulf in the winter. Specimens of the speckled trout, *Cynoscion nebulosus*, were found in trawl catches in the Gulf only in January. This fish was taken in trawls in the Gulf in Louisiana only in January, February and March (Gunter, 1938c). The flatfish, *Citharichthys spilopterus*, was absent from the bays in winter. *Achirus fasciatus*, the broad sole, was absent from the bays in January and was taken in the Gulf only from November to January. The two common sea robins, *Prionotus scitelus* and *P. tribulus* were absent from the bays in winter. The puffer, *Sphoeroides marmoratus*, was absent from January to March in the bays. Many less numerous fishes disappeared from the bays entirely and later also from the Gulf. None of the sharks and rays, with the exception of the stingaree, were caught in the winter. The bonefish, *Elops saurus*, the lizardfish, *Synodus foetens*, the needlegar, *Strongylura marina*, the threadfin, *Polydactylus octonemus*, all of th Carangidae except the pompano, *Trachitotus carolinus*, the rough silverside, the mojarras and the spadefish, *Chaetodipterus faber*, were all absent in the winter. The silver sardine, *Harengula macropthalma*, of the Gulf beach, also completely disappeared. Several other fishes taken only a few times were caught only in the Gulf in summer. The months when the various fishes appeared in the spring and summer or disappeared in the fall and winter or left the bays varied some with the species. This is shown in the tables. Examination of the tables of monthly catches will show that, taking all migrant species into consideration, the movement towards the Gulf started in October and continued into December. Likewise most fishes returned to the bays from February to April.

Over and over again it was noted that when a fish was present in both bays it disappeared in Copano Bay first and returned later than in Aransas Bay. For instance *D. sabina* was absent from Copano Bay from November to February, but was absent from Aransas Bay only in January. *G. felis* was completely absent in Copano Bay in January, but was taken in small numbers in Aransas Bay. The flatfish, *Citharichthys spilopterus*, was not found in Copano Bay from October to May, inclusive, but was absent from Aransas Bay only from January to March, inclusive. Many other examples of this case are shown in the tables.

The large general exodus of fishes from the bays in the fall is the most noticeable fact concerning the seasonal cycle. It also held true for the commercial shrimp, *Penaeus setiferus*, and the other peneids in the bays. However, there was a counter movement of a few species. After spawning the mullet and redfish returned to the bays and the catch of the black drum, *Pogonias cromis*, became much greater in the bays, especially in Copano Bay, in the winter. The Gulf hake, *Urophycis floridanus*, appeared in the Gulf and bays in the winter and although it remained until spring when the temperatures had risen considerably, it did not enter until a sharp drop in temperatures had taken place. This corroborates the same observation previously made by Gunter (1938c). In mild winters the fish possibly does not come into the bays at all. As was also previously noted in Louisiana, the sand

trout, *Cynoscion nothus*, which apparently prefers high salinities, did not enter the bay until the winter. Similarly, the tonguefish, *Symphurus plagiusa*, was not present in Aransas Bay except from November to April.

The size changes of the fishes, their gonadal condition, the temperatures at the time they started an exodus from the bays or the return migration are all factors in the seasonal cycle picture, but all facts cannot be given in a general account. In the text and accompanying tables they will be found for all fishes mentioned in this section, VIII, and some not mentioned.

Soon after the larger redfish and mullet return to the bays they are followed by hordes of young mullet, croakers and redfish, which work into the bays and spread out in the shallows. The first apparently goes farther into the bays than the croaker, but both reach Copano Bay by February. At about the same time the winter migrants enter the bays. The superabundance of *Anchoa mitchilli diaphana* and *Menidia beryllina peninsulae* on the bay flats gives way to *Cyprinodon variegatus variegatus* in midwinter. *Brevoortia* sp. spawns at this time in Copano Bay and the young soon enter the picture. The young croakers, mullet and menhaden grow rapidly and in the spring *A. m. diaphana* returns in large numbers on the bay flats. During the winter the oysters have fattened gradually (Gunter, 1942d), and soon show signs of spawning. As the temperature rises, *U. floridanus*, *C. nothus* and *S. plagiusa* leave the bay waters and the first departs from the area entirely. Small peneid shrimp come into the bays by millions, the crabs spawn in the shallow Gulf and lower bays, and many different fishes enter the bays including *Polydactylus octonemus*, which spends the winter beyond the area studied. The return of *U. floridanus* to the shallow Gulf and bay waters in the winter and its departure in the spring and the reciprocal migration of *P. octonemus* into the region in the spring and its departure in the fall are among the notable features of the seasonal movements of fishes in the bays and shallow Gulf. The catfishes return to the bays in large numbers in the spring and begin spawning activities. The speckled trout begins spawning at about the same time. In the spring and summer young pompano and *H. macropthalma* appear on the Gulf beach. The carangids, triglids and many rarely caught fishes return to the shallow Gulf along with several crustacea that are taken only in the summer. In midsummer and fall many of the fishes enter Aransas Bay and some even go into Copano Bay. The crab,, *Callinectes danae*, also enters the lower bay in summer as does a species of squid, *Loligo brevipinna* LeSueur. The Spanish mackerel, *Scomberomorus maculatus*, and other large scombrids and game fishes approach the Gulf shore and some of the mackerel enter the bays. As the temperatures drop in the fall the exodus of the shrimp and many fishes starts again and the cycle is completed.

Several species of fishes spawn in the Gulf near the passes. This also holds true for the common shrimp. The blue crab spawns in the Gulf or lower bay. The speckled trout, the two marine catfishes, the menhaden, *Brevoortia* sp., the anchovy, *A. m. diaphana*, and the silverside, *M. b. peninsulae*, are the chief species that spawn in the bays. The young of many fishes that spawn in the shallow Gulf work into the bays in the winter and spring. The bays act as a nursery ground for these fishes and for the common shrimp, *Penaeus setiferus*, and blue crab, *Callinectes sapidus*, as well as for those species spawned within their limits. These animals remain

in the bays and grow during the spring and summer. Most of the fishes that leave the bays when cool weather begins are the young which have been growing in this nursery area during the warm months. They are mostly from a few months to almost a year old. The other numerous component of the seaward fall migrants are the spawners going to the Gulf to spawn.

It appears that the temperature cycle is chiefly responsible for the seasonal movements and other recurrent cyclic activities of the fishes under discussion. The temperature cycle is definite while the general salinity changes are not nearly so regular. The winter and spring in general are the times of greatest rainfall but this is not always the case. A salinity gradient from a very high to very low salinity is more or less maintained at all seasons and a migratory animal could presumably take its choice so far as salinity of the environment is concerned. Such a wide temperature gradient is on the other hand not present at any given season in the shallow Gulf waters. In a few instances there are indications that either temperature or salinity is clearly more operative than the other factor in influencing the movements or presence of a species in a given environment at a given time, but mass movements coincide with the temperature cycle. Both of these important physical factors, salinity and temperature, have definite limiting and differential effects, which are difficult to separate merely by observation. Nevertheless, it appears that temperature is the chief factor affecting and initiating seasonal migrations and other seasonal cyclic actions of the fishes of this coast.

IX. Observations on Fishes Killed by Cold

The destruction of marine animals, especially fishes, by cold waves that strike the Gulf Coast of the United States every decade or so has received some attention from zoologists. Most observations concern the Florida Coast. Storey and Gudger (1936) reviewed the earlier papers of Packard (1871) (not seen by the writer), Willcox (1887) and Finch (1917). Bangs (1895) stated that the mortality of fishes in Florida in the cold winter of 1894–95 was greater than he had ever expected to see. Storey (1937) studied the relation between normal range and mortality of Florida fishes due to cold. Miller (1940) described the effect of the cold spell of that year on fishes of the southeast Florida Coast. Galloway (1941) gave notes on fishes killed at the same time at Key West.

The earliest account of the effect of sudden cold on Texas marine fishes known to the writer is that of Bartlett (1856) and I am indebted to Mr. J. L. Baughman for calling it to my attention. Parts of Bartlett's journal from pages 530–531 are quoted:

"Jan. 3—A violent norther arose during the night, and we had it piercing cold today. When in the house we were seated by fires, and when outside the doors, wrapped in our overcoats. Yet in spite of all our efforts it seemed almost impossible to keep warm, so penetrating are these winds to systems which have been relaxed.

"When these winds blow so violently they drive the water from the shallow lagunas into the Gulf, and increase the difficulty of navigating them. Many of the bars are then nearly dry. There is one in particular, across the mouth of Nueces Bay, which deserves to be noticed. When the tide comes into this bay, as well as in all others, it is resorted to by large numbers of fish from the Gulf, to feed. The water may then be from five to ten feet deep, and is the same temperature as that of the Gulf. But after a norther has blown for twelve or twenty-four hours, its temperature is so much reduced that the fish become chilled, and not having strength enough to make their way over the bar, now more shallow than ever, they often lie there is heaps. At these times the people go to the bar in their wagons, and with a spear or fork, pick up the finest fish, weighing from ten to 100 pounds, and thus carry away many loads. Many were brought in today and they proved a great luxury. * * *

"* * * In the remarkable journey of Alvar Nunes Cabeza de Vaca from Florida to Sinaloa on the Pacific Coast, between the years of 1527 and 1535, he remained for eight months among a tribe of Indians on the Gulf of Mexico, whom he calls the Avavares. "They are all," he says "ignorant of time, either by the sun or moon, nor do they reckon by the month or the year, but they better know and understand the differences of the seasons, when the fruits come to ripen, *the fish to die,* and the positions of the stars, in which they are ready and practiced.

"*The season when the fish come to die* has never been understood. When Mr. Buckingham Smith, the learned translator and commentator of the "Narrative of Cabeza de Vaca," asked me, on my return from Mexico, whether in my journey along the northern shores of the Gulf I had seen or heard anything that would

enable me to elucidate the passage in question, the incident I have named as happening annually on the bars of the lagoons, when the northers blow, at once occurred to me; and, on explaining what I had witnessed Mr. Smith at once agreed with me that this was the true solution of the passage."

Whether or not Mr. Bartlett's surmise is correct will probably always remain a moot question, for fishes along part of the South Texas Coast (Laguna Madre) and North Mexican Coast also die in some years during the summer in oversaline waters. Nevertheless, his is an interesting account of what happened during cold spells in earlier days when fish were probably more plentiful than at present. He refers to numbing of fish. Numbing is not necessarily followed by death in mild cold waves.

Higgins and Lord (1926) stated that Texas coastal waters were shallow and subjected to extremes of temperature which periodically reduced various species of fish. They specifically mentioned the cold spell of December, 1924.

Burr (1930) gave a short account of the cold spell of January, 1930. Many fish were only numbed but a great many were killed in Galveston and Copano Bays and the Laguna Madre. The chief mortality was said to be among mullet and sand trout. Species names were not given, but the species referred to were *Mugil cephalus* Linnaeus and *Cynoscion arenarius* Ginsburg. Two photographs were given of fishes killed by the cold, stranded on the bay shores near Corpus Christi.

The writer (1941b) gave an account of the fishes and invertebrates killed on the Texas Coast by the severe cold wave of January, 1940. Many kinds of fishes and several crustacean species were killed. It was estimated that roughly a million pounds of fish succumbed and this estimate was probably too low. It was predicted (Gunter, 1940) that a shortage of fish was to be expected for the next few years. A decline in the commercial fish catch was shown (Gunter, 1941b) for the months immediately following the freeze. Following the freeze the annual commercial catch of fish was the lowest on record for this coast. The average annual catch of Texas marine fishes is around three to four million pounds. This figure does not include the red snapper which are nearly all taken beyond the territorial waters of the state. In the fiscal year 1939–40 (August 31–September 1, part of the fiscal year being before the freeze) the catch was 2,136,159 pounds and for 1940–41 it was 2,079,237 pounds. In 1941–42 it was 2,983,134 pounds. In 1942–43 it was 3,766,126 pounds. For the three fiscal years prior to this freeze the annual catch averaged 4,772,829. It is seen that the annual catch did not approach the levels that held before the freeze until the third year afterward. Other conditions have remained the same on the Texas Coast and the freeze of January, 1940 is the only known major factor which could have caused a decline in the commercial fish catch. The Army bombing range mentioned previously (Gunter, 1941a) went into use after the close of the fiscal year 1940–41 and there is no evidence that this has had a deleterious effect on coastal fisheries.

Records, especially in earlier years, on great mortalities of fish because of cold on the Texas and Gulf coasts are far from adequate. However, the severest cold spells seem to have occurred in the years 1856, 1868, 1899, 1917, 1930 and 1940. This is an average interval of fourteen years. Other milder cold waves hit the coast at shorter intervals. According to the records of Storey and Gudger (1936),

fishes were killed on an average of every six years at Sanibel Island, Florida, from 1886 to 1934.

On January 1, 1942, a light cold wave struck the Texas Coast. In the Aransas Bay area it gave signs of dying out two or three times, but it continued for eight days and temperatures below freezing were attained on the nights of the sixth, seventh and eighth of the month. An air temperature of 28.0° F. was the lowest reached. It may be said that the cold was very light and came gradually.

No mortality of marine animals was expected, but a few reports of fish killed came in and some evidence was gathered first hand. The writer was conducting the regular monthly survey of the fish population of Copano and Aransas Bays and the adjacent Gulf of Mexico, so that information is available on the fish population of the area for December, 1941 and for January, 1942, immediately after the freeze.

Fishermen reported that sand trout, *Cynoscion arenarius,* and mullet, *Mugil cephalus,* were killed in the storm basin at Aransas Pass. Another reported that he saw two large redfish, *Scianops ocellatus,* and a large drum, *Pogonias cromis,* washed up on Long Reef, which is near the upper end of Aransas Bay. He surmised that the fish tried to cross the reef to deeper water, but being numb from the cold (like Mr. Bartlett's fishes of Nueces Bay) got stuck in the shallows and perished there. This covers the reports from fishermen on mortality of fishes. Speckled trout, *Cynoscion nebulosus,* caught on hook and line were too sluggish to pull hard and commercial fishermen stated that schools of them would only run a few feet when scared instead of leaving the vicinity, which is the ordinary reaction.

Table 71 gives the average temperatures and salinities of both bays at all stations visited for December and January. Seven different localities were visited in Copano Bay and thirteen in Aransas Bay. All January stations were visited after the freeze. Aransas Bay was visited first on January 12, 1942, three days after the cold spell was over. The average temperatures of the bay in January, shown in the table, give no indication of the water temperatures at the time of the freeze, for, as shown in the report of Collier (see Ann. Rep. Texas Game, Fish and Oyster Comm. 1937–38, p. 33), the air and water temperatures of shallow Texas bays parallel each other very closely and the temperatures had risen sharply by the time the January survey was undertaken. Water temperatures at the time of the freeze were not obtained for the regular monthly survey was not in progress because of rough weather. No mortality of marine animals was expected and special effort to get water temperatures at the time of the freeze was not made. During the hard freeze of January, 1940, the lowest temperature obtained was 4.0° C. in Aransas Bay. The lowest temperature found on January 12, 1942, three days after the freeze was 8.1° C. It must have been a degree or two lower during the last days of the cold spell. Table 71 shows that the salinity change was very little and mortality could not have been caused by this factor.

No dead animals were found in the Gulf of Mexico. Table 72 gives the numbers of live and dead fishes taken in Copano and Aransas Bays before and after the cold spell. The chief fishes killed were *Anchoa mitchilli diaphana, Menidia beryllina peninsulae, Galeichthys felis, Gobionellus hastatus* and *Cynoscion arenarius.*

One dead crab was encountered. The numbers of commercial shrimp, *Penaeus setiferus* Linnaeus, taken in December were estimated but not counted. It was

estimated that the numbers taken were between 4,900 to 5,600 for Aransas Bay and 500 to 600 for Copano Bay. Only two live shrimp were taken after the freeze, both in the lower end of Aransas Bay. Eighty-eight dead shrimp were taken in both bays.

No dead fishes or shrimp were found in the minnow seine or trammel net hauls. Sixty-one dead organisms were found in Aransas Bay and 113 were found in Copano Bay in shrimp trawls. Four trawl hauls were made in Aransas Bay and three in Copano Bay. Table 73 shows the numbers of dead and living of the three species of which dead individuals were common to both bays. The five anchovies and *Menidia* found dead in Aransas Bay were found in the upper bay near Copano Bay. A few more dead shrimp were taken in Copano Bay then in Aransas Bay, although the number of hauls were less by one, and, taking the evidence of the previous month, shrimp were much more abundant in Aransas Bay. These facts indicate rather conclusively that the effect of the cold was most extreme in Copano Bay. Copano Bay lies behind Aransas Bay and is almost surrounded by the mainland. As was stated in the introduction, it is also shallower than Aransas Bay.

A. m. diaphana is one of the most abundant fishes in Texas bays in winter both in numbers and species mass, as has been shown before. *M. b. peninsulae* is also very abundant close to shore. *G. felis* is not abundant in the bays in winter and *S. marmoratus* is present in comparatively small numbers at all times. Nevertheless, these two species are always killed in cold spells. Their susceptibility to cold must be much greater than that of the anchovy and silverside. *C. v. variegatus,* which is extremely abundant near shore, and other cyprinodontids were unaffected by the cold, as was observed also in 1941. Young *Mugil cephalus* were found in the shore waters of Aransas Bay in great numbers in January. They came in and remained in spite of the cold spell and were apparently unharmed.

Storey (1937) has shown that tropical fishes are killed more often by freezes at Sanibel Island, Florida than are subtropical species and these in turn are more susceptible to cold than temperate species. Except for *Galeichthys felis* none of the fishes killed here are given on her list, although *Sphoeroides spengleri* is close to *Sphoeroides marmoratus* listed here. All fishes killed here are subtropical and tropical or subtropical and temperate in distribution. It is noteworthy that table 72 indicates that *Synodus foetens, Trichiurus lepturus, Orthopristes chrysopterus, Eucinostomus* spp., *Cynoscion nothus, Achirus fasciatus* and *Etropus crossotus* were found in the bays before the freeze but not afterwards.

The criterion used for death from cold was simply the discovery of the dead animals, with no lesions, in trawls after the freeze. It may be questioned whether freezing was the cause of death, but in a few hundred hauls on the coasts of Louisiana and Texas in the past eleven years I have found only an occasional dead organism and never several dead organisms together, except in three instances after freezes. The close connection between the two uncommon events, freeze and mortality of fishes, leaves little room for doubt as to the cause of death.

In my former paper on Texas fishes killed by cold (1941b) *Anchoa mitchilli diaphana* Hildebrand and *Cyprinodon variegatus variegatus* Lacépède were incorrectly listed as *Anchoviella epsetus* (Bonnaterre) and *Cyprinodon carpio* Günther,

respectively. There is no record of the last named fish on the Texas Coast and *A. epsetus* is rare in bay waters during the winter.

Some years ago the writer (1938c) made the observation, previously noted by Hildebrand and Cable (1930) for fishes, that there was some indication that young poikilothermal marine animals survived sudden cold spells better than larger specimens. The question was raised again in the discussion of the 1940 freeze (Gunter, 1941b). The writer has looked forward for some years to a mild cold spell which would kill some members of a marine species and leave others alive, so that the question could be more critically evaluated. In the January, 1942, cold wave only two species of fishes, *A. m. diaphana* and *M. b. peninsulae*, satisfied the requirements. Only two live shrimp were taken and the dead shrimp were too disintegrated for measurement, so they were disregarded. In Aransas Bay, only five specimens of the two fishes were found killed at the upper end of the bay, although the living population was quite numerous. Towards the lower end, where the size distribution of the two populations may have been different, there was no mortality. At the same time there was a rise in salinity from the upper to the lower end of the bay from 15.6 to 24.9 parts per thousand. There seems to be some degree of positive correlation between the rise in salinity and the size of many marine organisms, which might becloud the issue. For that reason only the populations of the two fishes in Copano Bay were considered. Copano Bay was uniform in salinity at the time, the samples from the three trawl stations running 12.0, 12.0 and 12.6 parts per thousand, respectively. Dead fishes were found at all trawl stations in that bay.

Live *M. b. peninsulae* were taken throughout this study only in minnow seine hauls in Copano Bay. All those taken in trawls in Copano Bay were dead and they were found only following the freeze. *M. b. peninsulae* is extremely rare in trawl hauls in Texas, as has been shown before for Louisiana (Gunter, 1935). It has been observed before that occasionally certain fishes which live close to shore are taken in trawls during cold spells (Gunter, 1935, 1941b). This means that they leave shore and go to the open bay. There were similar instances here. Six live *M. b. peninsulae* were taken in trawls in lower Aransas Bay in Lydia Ann Channel immediately following the freeze and another was taken at the same place a month later when the temperature was still relatively low. The only *C. v. variegatus* taken in trawls in the course of this work was also caught after the freeze in Lydia Ann Channel. Presumably the fishes are numbed and carried to deeper water or they go there seeking warmer water.

The dead *Menidia* from Copano Bay were compared to the population near shore taken by minnow seines. Apparently the smallest *Menidia* did not venture into offshore water in any numbers, at least, for they were not taken by the trawl which caught small anchovies of the same size, both alive and dead. Curves comparing the total length-frequency of living and dead specimens of *A. m. diaphana* and *M. b. peninsulae* were drawn and they might appear to be slightly indicative of a differential effect of cold on the smaller and larger fish. However, due to the small numbers of the sample and the slight difference shown they cannot constitute proof. For that reason they are not presented.

Due to the inherent difficulties of making a field analysis, the whole question of a possible differential effect of cold on old and young poikilothermal animals deserves rigid experimental analysis in the laboratory. A small amount of experimental work has already been done on this subject. Pearse and Wharton (1938) in connection with their life history study of the marine turbellarian, *Stylochus inimicus* Palombi, found that young worms survived induced cold better than larger specimens did.

X. Distribution of Fishes in Relation to Salinity

The area where this work was carried on possesses many advantages for studying the relationship of marine animals to salinity. There is always a very wide salinity gradient present, extending from the head of the bays to the waters of the open sea. Occasionally salt water extends up into the river mouths, but usually water that is fresh or very nearly fresh may be found at the head of the bays and from there the salinity rises to 36.5 or even 36.8 parts per thousand at five miles offshore in the Gulf of Mexico. The latter salinities are a little higher than those of most oceans. Here within a distance of 40 nautical miles is found a salinity gradient covering the total range from fresh water to pure sea water. The region lies in the dry belt designated by Thornthwaite (Price and Gunter, 1943). The rainfall is partly, but not entirely seasonal, coming mostly in the winter and spring and the annual average is about 26 inches. The drainage of the coastal plain hinterland is not rapid and there is a lag of about one month following rainfall inland and the time the salinity in the bays shows a drop (Collier, 1938 and MS). The tides on the Gulf Coast vary only about 2 feet and are even less in the bays and at times there is only one tide a day. These factors all contribute to the maintenance of a stable, slow-changing salinity gradient in the bay and littoral waters of the Texas Coast. The hurricanes which strike the vicinity and the high tides that accompany them bring about rapid salinity changes, but these occurrences are not common.

The Texas bays are essentially large lagoons connected with the sea by narrow channels. In their salinity characteristics they are like bays and do not assume the characteristics of an estuary (with a mixture of a current of fresh water and the tide) except at the very upper parts near river mouths. Even here the mixing of fresh and salt water is gradual for the river flow is usually small and the tides are small. At times of heavy rains, fresh water flows out over the salt water for a little distance from the river mouths.

Several studies of brackish water and estuarine fauna and flora have been published. Some of the most important papers are cited in the bibliography. In Holland, Redeke (1922) studied the distribution of brackish water invertebrate animals in relation to salinity. Schliënz (1923) studied the distribution of 21 species of crustaceans in the Elbe River where the salinity ranged from 0.47 to 17.12. Percival (1929) studied faunal distributions as related to salinity in the estuaries of the Tamar and Lynher rivers in Wales. No particular study of fishes in such an area has been made. Robson (1925, cited by Pearse, 1936, not seen by the writer), who worked in the Thames estuary, classified the estaurine fauna into three elements, permanent indigenous species, seasonal migrants and stragglers. The same classification can be applied to the area under consideration. The shrimp, *Palaemonets vulgaris*, the several cyprinodontids, *Gobiosoma bosc*, *Opsanus beta*, *Opsanus* sp. and *Gobiesox strumosus* are examples of species indigenous to the bays. *Urophycis floridanus*, *Polydactylus octonemus*, *Cynoscion nothus* and several other fishes and some invertebrates are seasonal migrants into the bays. The best example of stragglers are the four fresh water fishes and the river shrimp, *Macrobrachium*

ohionis (Smith). Gunter (1937) has shown that the latter species comes into the bays when the salinity is low.

In table 74 an attempt was made to classify the most common fishes on the basis of the salinity of the water in which they were caught. These classifications are somewhat arbitrary in that some species did not fit any grouping precisely, as can be seen by examination of the table on the numbers of fishes caught at various salinities, but most of the fishes fit into the groupings listed. First are those fishes taken only at very low salinities. The fishes in this list are four fresh water stragglers into the bays. Except for one specimen they were all taken at salinities below 3.3. In the next category are those fishes which were taken most abundantly at low salinities, but which were absent or uncommon at high salinities. Four fishes are in this group. There is some question about the advisability of including *Archosargus probatocephalus* in this group, since the numbers of the fish caught were small. Fishes most abundant at low salinities, but which were also taken in some numbers at high salinities, include one cyprinodontid and the four chief commercial species of the Texas Coast, *Sciaenops ocellata, Pogonias cromis, Cynoscion nebulosus* and *Paralichthys lethostigma.* The next group includes those species taken most often at medium salinities. Six fishes are in this category. The numbers caught were small. *Bagre marina*, the gafftopsail catfish, leaves the bay and shallow Gulf area, except for stragglers, in the winter. Doubtless, the fish goes out into saltier water, so that the salinities at which it was taken do not give a true picture of relation of the distribution of the fish to salinity, except for the time that it is within the area. This same qualification should be held in mind in connection with other seasonal migrants that come into waters of low salinity in the warm months. The next group includes those fishes which were taken most often at high salinities, but which were less common, rare or absent at medium and low salinities. Twenty species are included. The last group lists the eight fishes which were taken in large numbers at all salinities. It includes nearly all of the most numerous species or those of greatest species mass discussed in the preceding topic.

Redeke (1932) maintains that the physical factors of the environment play a subordinate role compared to that of the chloride content of the water in influencing the spread and distribution of brackish water animals. He has divided brackish water into oligohaline, mesohaline and polyhaline zones. Brunelli (1929) and Gurney (1929) (cited by Redeke, *op. cit.*, and not seen by the author) on the other hand feel that the salt content of the water is not the only important factor determining spreading of brackish water animals, but that temperature, depth, bottom composition and current rate are also important.

Pearse (1936) has remarked that many marine animals can tolerate dilution of sea water. Euryhalin animals are those which can live in both fresh water and sea water. Since we know little about the lengths of time an animal can or may live in either of these environments the writer (Gunter, 1942a) has defined a euryhalin fish as one which has been recorded in both fresh water and sea water under natural conditions. Several of the fishes listed in table 74 are euryhalin according to that definition, although the table shows that some are fishes which live mostly in waters of high salinity and venture rarely into low salinities.

Percival (1929) found that the number of marine animals dropped off sharply when the salinity dropped below 2.5 per cent, but a number persisted in salinity as low as 2.0 per cent. In table 75 the species of fishes taken above certain salinities but not at lower salinities are given, irrespective of the numbers caught. The four fresh water species are disregarded.

Table 75 shows that 25 species of fishes were not caught in water with a salinity below 30.0. More extensive future collecting may show that some of them venture into less salty water, but in the light of present information this group may be classed as purely marine. Eleven species were caught where the salinity was below 30.0, but not at salinities below 25.0. The first two groups consist of fishes that do not venture often, if at all, into water that is diluted greatly below sea water. It is known that *Pomolobus chrysochloris*, which was included in this group on the basis of the record, ventures several hundred miles up river.

The group containing fishes taken below a salinity of 25.0 but not taken where the salinity was below 20.0 contains only six species. Baughman (1941a) has shown that *Lobotes surinamensis*, listed therein, goes into less saline water than this record shows.

In the group that was taken below a salinity of 20.0 but not taken where the salinity was below 15.0 there are 12 species and 15 in the group taken below a salinity of 15.0 but not below a salinity of 10.0. There are six fishes in the next group, those taken below a salinity of 10.0 but not below 5.0, and 39 species taken where the salinity was below 5.0 per thousand. This last group, like the group that was not taken below a salinity of 30.0, is large. It includes all the most numerous fishes caught and all the bay or brackish water fishes. Twenty-three of the species of this group were also taken in water where the salinity was above 30.0. In short, the fishes of this group are largely euryhalin.

Only 17 species out of 119 caught were not taken where the salinity was above 30.0 and doubtless several of these fell into the low salinity groups fortuitously, for their numbers were small. Of those not taken at high salinities it is known that *Tarpon atlanticus, Pomolobus chrysochloris, Hippocampus regulus, Pomatomus saltatrix, Lobotes surinamensis, Prionotus beanii* and *P. punctatus* are taken at times in pure sea water. The position of *Hemicaraux rhomboides* is uncertain. The remaining fishes *Signalosa mexicana, Mollienisia latipinna, Lucania parva venusta, Syngnathus mackayi, S. scovelli, Gobiesox strumosus, Opsanus beta* and *Opsanus* sp. are more truly brackish water fishes, although doubtless most or all of them can withstand higher salinities. It is known that *M. latipinna* can withstand very high salinities, see Herre (1929). An examination of table 4 shows that few species were not taken at high salinities, but that several were not taken at the lower salinities. In brief, practically all the fishes studied in this estuarine, brackish water, bay and marine area can tolerate high salinities, but many of them do not tolerate waters of low salinity in nature.

The seasonal movements of fishes are largely determined by temperatures as has been shown in a previous topic. *Polydactylus octonemus, Urophycis floridanus* and *Cynoscion nothus* enter the bays only seasonally, the first in summer and the last two only in winter. They enter the bays and go into waters where the salinity is low, but only seasonally, apparently when the temperatures are suitable. The

remainder of the time they live in waters of very high salinity. The same remarks doubtless hold true for many of the summer migrants into the bays. In the fall and early winter many fishes leave the bays. Some of them go to the Gulf to spawn and it is quite possible that the spawning migrants prefer waters of higher salinity at that stage in their life history. However, many fishes are not on a spawning migration. It is most reasonable to assume that they move out not because of a sudden preference for high salinities, but because of lowering temperatures in the bays.

The Cyprinodontes have long been noteworthy for their ability to withstand wide ranges of salinity. Nevertheless, on the Texas Coast they are inhabitants of the bays and except for stragglers near the passes they do not enter waters of higher salinity in the Gulf. An examination of their distribution and its relation to salinity shows, therefore, that these fishes apparently prefer medium salinities. This is doubtless true for some of them, but the exclusion of all the Cyprinodontes from the saline waters of the Gulf is in all probability determined by the lack of cover on the Gulf beach and not intolerable salinities. Some of the cyprinodontids live freely in the bays in waters with salinities equal to or higher than those in the Gulf, as has been shown in the topics on individual species. Chidester (1922) says temperature and stream flow are more important to *Fundulus heteroclitus* than is salinity.

The fact that only five fresh water species were taken in salt water, counting *Dorosoma cepedianum*, which is more or less anadromous (Gunter, 1938b), is significant. They composed 5.3 per cent of the species and less than 0.02 per cent of the specimens taken. As has been pointed out before (Annandale 1922, Pearse 1936, Gunter 1942a) the fauna of brackish water is marine. Pearse (*op. cit.*, p. 36) says that "perhaps freshwater animals are less likely to become adjusted to salt water than are salt water animals to become adjusted to various dilutions." This deduction naturally follows from the previous observation. Brandt (1896) found in the Kaiser Wilhelm Canal, which runs from the North Sea to the Baltic and also connects with the Eider River, that marine animals had entered from either end and lived in water varying in salinity from 4.7 to 19.0 per thousand, but only a stonefly and beetle larvae had come in from fresh water. They were found near the mouth of a river and the author said they were only accidental or casual strays. Percival (1929) found only 2 fresh water species, a tubifex worm and an isopod, among a total of 176 species in the estuaries of the Tamar and Lynher rivers in Wales. The remaining species were brackish water or marine types. The writer's observations on fishes recorded here and in previous work are in agreement with Brandt's and Percival's findings. It was found (Gunter, *op. cit.*) that the marine fishes which have been taken in fresh water in North America outnumber fresh water fishes which have been taken in sea water by nine to one. The fact that many of the fishes taken in this work were not found in waters of lowered salinity is not contrary to the conclusion that marine animals accustom themselves to lowered salinity better than fresh water fauna adjusts to raised salinity. Conversely, it is shown here *(vide supra)* that practically all of the fishes taken in waters of very low salinity, except for the fresh water species, can also live in waters of high salinity.

Annandale (1922) holds that brackish water and estuarine areas are refuges "for spent races" or primitive types which have been unable to compete with more progressive marine animals. There is no indication of such a condition on the Texas Coast. Among the most abundant larger animals here are palaemonid and peneid shrimps, the blue crab, and the anchovies, menhaden, Cyprinodontes, mullet, silversides and sciaenids. Some are primitive, but none are decadent or spent. The virility of the Sciaenidae has been remarked upon previously (Gunter, 1938a). The virility of the Cyprinodontes is proverbial. There are many species of gobies in this area. The gobies are considered to be undergoing rapid evolution.

Many species of common fishes spawn in the bays. Some of them are the menhaden, *Brevoortia* sp., the anchovy, *Anchoa mitchilli diaphana*, the Cyprinodontes, the two marine catfish, the silverside, *Menidia beryllina peninsulae*, and the speckled trout. The young of the mullet, drum, redfish, croaker and others, also enter the bays and grow up there. Small specimens, but not necessarily the smallest sizes, of several fishes enter the bays. Small jackfish, *Caranx hippos*, are often taken in the bays, although the larger fish are common only in the Gulf. Every summer, small specimens of the ling, *Rachycentron canadus* (Linnaeus), approximately 25.0 cm. long are taken in the bays by pole and line fishermen, but the adults are never seen except in the open sea. The predilection of the young of this species for waters of low salinity was indicated by Fisher (1891), who recorded a small specimen from a tributary of the Hudson River. There are many other examples. The young of *Penaeus setiferus*, *P. aztecus* and *Callinectes sapidus* also enter the bays and grow up there. In brief the brackish water areas of this coast are the nursery grounds for large numbers of fish and crustacea. This does not mean that the bays are nursery grounds only, for many fishes spend their whole lives there and many of the bay fishes that spawn in the Gulf spend most of their lives there.

XI. Size Distribution of Fishes in Relation to Salinity

When the writer first began collections of animals on the Louisiana coast in 1931, over an area with a wide salinity gradient, it was noted that fishes and peneid shrimp taken in waters of low salinity were smaller than specimens of the same species taken in waters of high salinity. It was further noticed that there seemed to be a gradual increase in the size of the specimens as the salinity of the water increased. The work was done in connection with the Shrimp Investigations of the U. S. Bureau of Fisheries and few measurements of fishes were made. Similar general field observations of the same phenomenon were made in Texas. It is particularly clear in trawl catches extending over a wide salinity range, made not long apart.

The literature on this problem was not examined for some years later. Vernon (1903) stated that the plutei larvae of a sea urchin "attained greater size than the normal when kept in moderately diluted water, and probably a smaller size when kept in concentrated water." Metcalf (1904) found dwarfs of the gastropod *Neritina virginea* var. *minor* from almost fresh water in Jamaica and similar dwarfs from very salty, shore ponds on the same island. He said the optimum salinity should be worked out. Flattely and Walton (1922) stated that the optimum salinity for most species of rock shore forms is unknown, but that only those mussels situated some distance up from the mouth of an estuary grow to marketable size. Metcalf (1930) called attention to his observations again, following the paper of Federighi (1930), who found that the size of the Atlantic oyster borer, *Urosalpinx cinerea* Say, was smaller at Beaufort, N. C., than at Norfolk, Virginia. The average salinity was highest at Beaufort. In a footnote Federighi stated that larger animals had been found in England where salinities were also higher. This paper and the method in which the work was done has more relation to zoogeographical variation and salinity and possibly temperature than it does to size distribution of a local population and salinity. Rice (1930) found that barnacles in Puget Sound were more crowded and smaller in lower salinities than they were in higher salinities. Milne (1940) who worked on sessile organisms on buoys said, "Generally the organisms become less numerous and smaller towards the lower end of their salinity range, as very obviously shown without measurement by *Laminaria* and *Mytilus*."

Ehrenbaum (1890) found that the young of the shrimp, *Crago vulgaris*, were found from spring to late summer far upstream in the brackish water of the Dollart and Jader Rivers in contrast to the adults which were found in strongly salt water. Havinga (1930), working on the same species in Holland, found that the young moved much farther into waters of lowered salinity than the adults did. Weymouth, Lindner and Anderson (1933) found that the young of the shrimp *Penaeus setiferus*, along the South Atlantic and Gulf Coasts of the United States, "move, in general, seaward through the summer and fall, so that there is always a gradient of decreasing size from the waters of greater salinity toward fresh water." Viosca (1920) had previously made similar observations on the same species.

Indications of a relationship between the size of fish and the salinity of the water has been shown for 22 species of fishes, previously discussed in this paper. They are: *Harengula macropthalma, Brevoortia* sp., *Dorosoma cepedianum, Signalosa mexicana, Anchoa hepsetus, Anchoa mitchilli diaphana, Galeichthys felis, Fundulus grandis, Fundulus similis, Menidia beryllina peninsulae, Membras vagrans vagrans, Mugil curema, Polydactylus octonemus, Chloroscombrus chrysurus, Orthopristes chrysopterus, Bairdiella chrysura, Cynoscion arenarius, Cynoscion nothus, Citharichthys spilopterus, Etropus crossotus, Achirus fasciatus,* and *Symphurus plagiusa.* For most of them it was merely shown that the largest fish were taken only in saltiest water. *Dorosoma cepedianum* is probably the clearest example of a species which showed progressive increase in the size of the fish as the salinity of the water increased. The fact that a relationship between salinity and size was not shown by means of length-frequency curves when all catches at all seasons are used does not necessarily mean that a size gradient related to the salinity gradient was not established for a species at some time of the year or at some time of the life history. If all hauls are used, the fact that many fishes hatched at higher salinities than the young later lived in tends to obscure any subsequent gradients that might be established.

It has been shown in this paper that the young of many species of fishes, for instance the mullet, croaker, redfish and drum work into the bays after hatching in the Gulf near the passes. The same thing holds true for the peneid shrimp, *Penaeus setiferus* (Weymouth, Lindner and Anderson, 1933) and *P. aztecus.* This means that the young, except for the very earliest stages, which are mostly too small to be caught in the nets used, are then in waters of low salinity. When the temperatures drop in the fall a huge, slow general migration of most of these fish into or in the general direction of the Gulf begins. They have grown rapidly during the summer and their numbers are reinforced by other species, spawned in the bays, which have also grown during the summer. This means that the fishes move into saltier water as they grow larger. The same thing applies to the peneid shrimp. They grow less during the winter and their numbers are diminished by the time they return to the bays again in the spring and summer. Here they are outnumbered by the large numbers of young of the year. This means that most of the fishes and some of the crustacea of this area undergo a definite annual salinity cycle, by virtue of their own movement, parallel to the temperature cycle, which in contrast comes to them, and in such a way that there is a direct relation between the size of the fishes caught and the salinity of the water. The smaller fishes are caught in lower salinities and the larger fishes are caught in higher salinities. It is seen then that the early life cycle and seasonal movements of fishes are such that intrinsically the fishes are distributed with a relation between salinity and size. Since the seasonal cycle of movement is apparently determined by the temperature cycle the question arises as to whether there is a real relation between size and salinity or is the apparent relation coincidental. It should also be pointed out that the young of many species live largely in the shallows and do not enter deeper water until they are larger. The shallows in general are a little less salty than adjacent offshore waters. It has been shown that the young of the common river shrimp, *Macro-*

brachium ohionis, do not venture into deep water as often as the adults do (Gunter, 1937).

Since the relation between the size of fishes and the salinity of the water was detectable as a general observation in the field, it was decided to work out the relationship of a species taken at a given time. For this purpose it was necessary to use a species taken in large numbers, over a wide salinity range, at a time when it was not breeding, so that the very young, often spawned in saltier water, would not confuse the issue. The croaker, *Micropogon undulatus*, fitted the requirements perfectly. Furthermore the overall data showed no relation between salinity and size for this fish. The data taken in the months of July, August and September, 1941 were used, and catches greater than eight days apart were not used, so that confusion caused by the factor of growth would not be introduced. Figure 10 shows definitely that a relationship between the size of croakers caught and the salinity of the water did exist during these months. In midsummer, migration or seasonal movements caused by temperature change were not operative and the relationship between the salinity gradient and size of the fishes was apparently real and not fortuitous or merely a coincidental result of the temperature cycle. Similarly, figure 11, shows that a relationship between salinity and the size of the silverside, *Menidia beryllina peninsulae*, existed in the months of November and December, 1941 and January, 1942. The same relationship possibly could be shown for other fishes taken in large numbers, but further analyses were not made.

XII. Summary

1. The relations of distributions of marine fishes to salinity of the water are little known. Such information is a necessary part of fishery biology and is fundamentally related to problems of physiology, ecology, zoogeography and evolution. Chief purpose of this study was to get facts on the distributional relationships of Texas coastal fishes to salinity. Certain effects of temperature on fishes were also studied and life history notes were made.

2. Texas has a double coastline of barrier islands and mainland shore. The coastal lagoon between connects with the Gulf of Mexico by few narrow channels through the islands. Landward from the lagoon lie more recently embayed back bays into which the rivers flow. The area where the study was made was Copano Bay, a back bay, Aransas Bay, part of the lagoon, and the adjacent Gulf of Mexico out to five miles offshore and five miles south on the Gulf beach from Aransas Pass. Here in a running distance of forty nautical miles is a salinity gradient ranging from almost fresh water at upper Copano Bay to pure sea water in the open Gulf. Rainfall is small, drainage is slow, and tidal exchange is small, so that the salinity gradient is relatively stable. The bays have a marginal area of shallow flats composed of sand or mud, with deposits of oyster shell and covered in many places with growths of algae and grass. The deeper part of the bays have mud bottoms, except for the oyster reefs which were not studied. The Gulf beach is barren sand and the offshore bottoms are mud. The deepest part of Copano Bay is 8 feet deep, the deepest part of Aransas Bay is 13 feet deep and the deepest offshore station in the Gulf was 60 feet deep.

3. Fishes were caught at regular stations visited once a month when possible. Work extended from March, 1941 to November, 1942, but was most intensive from June, 1941 to August, 1942, inclusive. Small fish were caught on the bay flats and Gulf beach in minnow seines. Large fish were caught on the bay flats in trammel nets and on the Gulf beach by beach seines. Small and medium-sized fish were taken in the offshore waters of the bays and Gulf with shrimp trawls. There were ten minnow seine stations in the bays and two on the Gulf beach. There were eight trammel net stations in the bays and two large seine stations on the Gulf beach. There were seven trawl stations in the bays and two in the Gulf of Mexico.

4. At stations all fishes were counted by species and up to fifty of each species were measured in total length. The gonadal condition and the stomach contents of some of the larger fishes were noted. Water temperatures were taken and salinity was determined by use of hydrometers. Average salinities in parts per thousand in Copano Bay, Aransas Bay and the Gulf of Mexico were 9.1, 20.5 and 31.5, respectively. The temperature at the stations varied from 7.8° to 34.0° C. In the text the monthly catch records, the seasonal movements, various life history notes and distributions of the fish at various salinities are discussed.

5. One hundred and nineteen species and 78,265 specimens were caught. Fourteen thousand seven hundred and ninety-six fishes were taken in the Gulf and 63,469

were taken in the bays. Seventy-two species made up less than 1.5 per cent of the catch. Fourteen species were taken over a thousand times each. The croaker, *Micropogon undulatus*, the bay anchovy, *Anchoa mitchilli diaphana*, the silverside, *Menidia beryllina peninsulae*, the sheephead minnow, *Cyprinodon variegatus variegatus*, and the mullet, *Mugil cephalus*, were taken over 5,000 times each and the first three species made up almost half the catch, being caught 36,956 times. It was estimated that the anchovy, *A. m. diaphana*, the menhaden, *Brevoortia* sp., the mullet, *M. cephalus*, and the croaker, *M. undulatus*, have the largest species masses of any fishes on the Texas Coast. Fishes of the families Sciaenidae, Engraulidae, Atherinidae, Cyprinodontidae, Mugilidae and Clupeidae were most often caught in that order.

6. Trawl catches of fishes compared to catches made in a previous study in Louisiana were similar. The croaker, *M. undulatus*, and the anchovy, *A. m. diaphana*, were very abundant in both places. Two catfishes, *Bagre marina*, and *Galeichthys felis*, the threadfin, *Polydactylus octonemus*, and the sand trout, *Cynoscion nothus*, were relatively more abundant in Texas waters, while the cutlass fish, *Trichiurus lepturus*, the star drum, *Stellifer lanceolatus*, and the banded drum, *Larimus fasciatus*, were much less abundant on the Texas Coast. Several specimens of the gizzard shad, *Dorosoma cepedianum*, the rough scad, *Trachurus lathami*, the pinfish, *Lagodon rhomboides*, the pigfish, *Orthopristes chrysopterus*, and the white mullet, *Mugil curema*, were caught in trawls in Texas, but not in Louisiana. In each place a few rarely caught species were taken that were not taken in the other.

7. The most numerous fishes on the bay flats of the Texas Coast were the silverside, *M. b. peninsulae*, the cyprinodontid, *C. v. variegatus*, the anchovy, *A. m. diaphana*, the mullet, *M. cephalus*, and the cyprinodontid, *Fundulus similis*. The silverside and the cyprinodontids are not caught in the Gulf or in deep water, with very rare exceptions. They are typical of the bay flats. The most abundant fishes in the deeper waters of the bay were the croaker, *M. undulatus*, the anchovy, *A. m. diaphana*, the catfish, *G. felis*, and the sand trout, *Cynoscion arenarius*. On the Gulf beach the most abundant fishes were the sardine, *Harengula macropthalma*, the anchovies, *A. m. diaphana* and *A. hepsetus*, the threadfin, *P. octonemus*, and the pompano, *Trachinotus carolinus*. In the deeper Gulf waters the most abundant fishes were the sand trout, *Cynoscion nothus*, the croaker, *M. undulatus*, the threadfin, *P. octonemus*, the catfish, *G. felis*, and the moonfish, *Vomer setapinnis*.

The larger fishes most commonly taken on the bay flats were the mullet, *M. cephalus*, the speckled trout, *Cynoscion nebulosus*, and the redfish, *Sciaenops ocellata*. The most common large fishes taken on the Gulf beach were the spot, *Leiostomus xanthurus*, the mullet, *M. cephalus*, and the stingaree, *Dasyatis sabina*.

8. During the fall most fishes in the bays began to move toward the Gulf. The absence of a species was generally first noticed in Copano Bay and it later became noticeable in Aransas Bay. Many species were only taken in the Gulf in the winter. Several other species left the area entirely. In the spring and summer the fishes return to the bays. There was a counter movement of a few species that were taken in the bays only in the winter. Seasonal movement of fishes is a result of temperature change and the influence of salinity is minor.

9. A mild cold spell in January, 1942, killed several fishes. The most numerous animals killed were the two fishes *A. m. diaphana* and *M. b. peninsulae* and the peneid shrimp, *Penaeus setiferus*. The effect of the cold was more severe in Copano Bay than in Aransas Bay. No fishes were found killed by cold in the Gulf of Mexico.

10. The spring of the year is the time of greatest spawning activity among the marine animals of the Texas Coast. Most fishes spawn at times of rising or warm temperatures, but several numerically important species spawn at the season of falling or low temperatures. Several of the winter migrants from the bays go to the shallow Gulf to spawn.

11. Several of the most numerous species spawn at medium or low salinities in the bays, while many other species spawn in saltier water in the Gulf of Mexico.

12. The bays are not refuges for spent races. They may be more correctly characterized as nursery grounds for many coastal fishes and crustacea. They are not nursery grounds alone. Many coastal fishes spend most of their lives in the bays.

13. The fauna of brackish water is marine and the fresh water element in it is negligible. A great many marine animals can withstand salinity dilution, but very few fresh water animals can withstand increase in salinity.

14. Many fishes were taken only at the highest salinities and several species taken at medium salinities were not taken at the lower salinities. In contrast practically all fishes taken at the very lowest salinities were also taken at the higher salinities. Practically every fish found living at lower salinities, except for four fresh water fishes, can also live in sea water.

15. There is a relationship between salinity of the water and size of fishes in that the smaller specimens were usually found in the freshest water and the largest were usually found in the saltier water. Many examples of this are shown in the paper, but the situation is not simple and there were exceptions to it. In general the size of fishes increased as the distance covered by the salinity gradient was traversed from lower to higher salinities.

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TABLE 1

The number of hauls made with different gear are given for all months for the two bays and the Gulf of Mexico

	1941										1942									
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Sept.	Oct.	Nov.
Trawls																				
Copano Bay	—	2	3	3	3	2	3	3	3	3	3	3	3	3	3	—	2	—	—	—
Aransas Bay	2	1	—	3	3	2	4	4	4	4	4	4	5	3	—	—	3	—	—	—
Gulf	—	—	—	1	3	2	2	2	2	—	2	—	3	2	2	—	—	—	—	—
Minnow Seines																				
Copano Bay	—	—	—	4	4	2	4	4	4	4	4	4	4	4	4	4	4	—	—	—
Aransas Bay	—	—	—	7	6	2	7	6	6	6	6	6	5	6	6	6	6	—	—	—
Gulf	—	—	—	2	3	2	2	2	2	2	2	2	4	2	—	2	2	2	2	2
Trammel Nets																				
Copano Bay	—	—	—	3	3	3	4	4	4	4	4	4	4	4	4	4	4	—	5	—
Aransas Bay	—	—	—	2	3	2	3	4	4	4	4	4	6	4	4	4	4	—	4	—
Beach Seines																				
Gulf	—	—	—	—	2	—	—	2	4	2	2	2	3	2	—	2	2	—	—	—

TABLE 2

The number of temperature readings, range and average of all readings in Copano Bay, Aransas Bay and the Gulf of Mexico are given for each month. Readings are in degrees centigrade

	Copano			Aransas			Gulf		
1941	Number of readings	Range	Average	Number of readings	Range	Average	Number of readings	Range	Average
March	---	---	---	4	17.2–19.5	18.1	---	---	---
April	4	21.0–22.0	21.5	2	23.0–24.0	23.5	---	---	---
May	5	27.2–30.0	28.0	---	---	---	---	---	---
June	11	28.0–32.0	29.4	10	28.2–33.0	30.7	2	27.0–30.5	28.8
July	13	28.0–34.0	29.6	11	27.2–34.9	30.0	7	28.0–29.2	28.6
Aug.	9	29.0–32.0	30.0	6	26.6–33.0	28.9	6	27.0–30.5	29.1
Sept.	14	27.1–30.5	28.8	17	28.5–32.0	29.6	6	29.0–29.7	29.5
Oct.	14	23.0–31.3	21.7	17	25.4–28.5	27.0	8	28.2–28.8	28.5
Nov.	14	14.9–23.3	19.0	18	14.4–27.0	19.4	8	15.5–24.5	20.8
Dec.	13	14.6–19.5	16.8	17	14.0–22.5	16.1	3	16.0–18.3	18.1
1942									
Jan.	14	12.3–17.5	14.9	18	7.8–16.9	11.9	8	9.7–17.0	14.3
Feb.	14	10.6–18.5	16.0	18	11.1–16.5	13.5	---	---	---
March	14	13.0–22.2	16.9	19	15.5–19.4	18.1	10	15.4–20.2	18.2
April	12	21.4–26.0	23.7	15	21.6–26.0	23.9	8	19.7–23.2	21.5
May	14	22.4–27.2	24.4	9	26.0–31.0	28.3	4	23.3–25.9	24.6
June	7	29.6–33.2	31.3	7	29.1–33.0	30.0	4	29.0	29.0
Aug.	10	29.4–31.0	30.1	16	28.4–32.0	30.4	4	29.5–30.7	30.3
Sept.	---	---	---	---	---	---	2	28.6–28.8	28.7
Oct.	5	20.2–25.8	22.8	4	23.5–25.0	24.4	2	20.5	20.5

TABLE 3

The number of readings, range and averages of all salinity readings are given for Copano Bay, Aransas Bay and the Gulf of Mexico for each month. The readings are in parts per thousand

	Copano			Aransas			Gulf		
1941	Number of readings	Range	Average	Number of readings	Range	Average	Number of readings	Range	Average
March	---	---	---	4	9.8–18.0	12.8	---	---	---
April	4	10.0–11.2	10.6	2	17.3–23.0	20.2	---	---	---
May	6	2.0– 2.3	2.1	---	---	---	---	---	---
June	12	0.0– 5.0	2.7	13	1.8–18.3	6.4	4	31.1–34.2	32.1
July	13	2.1– 4.9	3.4	14	5.2–36.4	21.0	8	33.9–35.8	35.1
Aug.	8	2.1– 6.3	2.8	7	13.2–37.2	27.1	6	36.4–36.8	36.6
Sept.	13	3.7–12.7	8.7	17	17.1–37.1	28.0	6	35.2–36.8	36.4
Oct.	14	6.6–11.6	9.8	18	14.0–30.7	18.7	8	28.1–30.9	30.3
Nov.	14	8.4–13.7	11.3	18	13.3–30.1	19.9	8	28.0–31.2	30.3
Dec.	14	10.0–12.4	12.1	18	12.1–27.4	19.0	4	28.7–30.4	29.5
1942									
Jan.	14	10.2–13.9	12.0	18	14.7–24.9	17.4	8	25.0–33.0	27.9
Feb.	13	2.3–12.6	10.1	18	8.8–31.7	20.1	4	27.9–29.3	28.7
March	14	11.1–15.7	13.0	19	16.7–34.2	27.1	13	30.8–35.2	33.4
April	13	13.2–14.7	13.8	15	17.7–29.0	24.4	8	28.5–30.7	29.7
May	13	15.2–18.4	16.4	10	18.0–32.4	23.7	4	26.6–33.6	28.4
June	8	17.7–20.4	18.5	10	18.2–34.0	26.5	4	30.1–31.0	30.6
Aug.	12	3.2– 5.7	4.5	16	9.1–35.6	22.9	4	34.9–36.6	35.9
Sept.	---	---	---	---	---	---	2	28.4–28.7	28.6
Oct.	5	3.3– 4.6	4.1	4	7.4–23.9	12.9	2	29.9–32.4	31.2
Totals	190	0.0–20.4	9.1	221	1.8–37.2	20.5	93	25.0–36.8	31.5

TABLE 4

The numbers of fishes taken at various salinities are shown. The salinities are divided into groupings of 5 parts per thousand

Salinity	0.0–4.9	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–
Dasyatis sabina	6	2	20	31	10	24	137
Lepisosteus spathula	19	———	5	———	———	———	1
Harengula macropthalma	3	———	4	6	3	947	972
Brevoortia sp.	242	78	464	365	93	12	28
Dorosoma cepedianum	212	58	356	52	8	5	1
Signalosa mexicana	3	7	27	166	20	6	———
Anchoa hepsetus	34	5	———	2	9	76	1,157
Anchoa mitchilli diaphana	2,019	453	2,962	1,922	1,333	894	1,471
Bagre marina	41	102	129	201	252	93	53
Galeichthys felis	170	205	512	719	275	202	1,185
Synodus foetens	———	———	1	7	10	2	14
Lucania parva venusta	78	10	355	21	12	———	———
Fundulus grandis	63	114	114	72	66	20	2
Fundulus similis	107	103	136	195	295	346	163
Adinia multifasciata	———	1	6	12	20	5	———
Cyprinodon variegatus variegatus	432	455	2,856	805	2,160	30	178
Urophycis floridanus	———	———	1	13	10	———	26
Menidia beryllina peninsulae	1,618	576	1,305	3,007	1,230	764	1,554
Membras vagrans vagrans	242	11	22	113	7	37	278
Mugil cephalus	177	180	409	2,966	521	344	446
Mugil curema	24	9	40	96	63	68	153
Polydactylus octonemus	416	39	13	181	71	166	1,451
Trichiurus lepturus	———	———	2	8	42	4	30
Poronotus triacanthus	———	———	———	10	———	5	32
Caranx hippos	1	1	———	8	———	2	30
Chloroscombrus chrysurus	———	———	———	61	———	1	82
Orthopristes chrysopterus	———	———	5	30	8	61	188
Lagodon rhomboides	205	98	64	76	130	104	230
Archosargus probatocephalus	8	2	10	4	———	1	———
Bairdiella chrysura	35	17	27	33	65	4	55
Stellifer lanceolatus	———	1	5	50	4	53	288
Sciaenops ocellata	102	39	128	20	14	23	29
Leiostomus xanthurus	121	162	54	362	130	163	372
Micropogon undulatus	4,873	899	3,521	2,464	2,002	749	1,349
Menticirrhus americanus	———	———	2	39	5	65	215
Menticirrhus littoralis	———	———	———	2	1	8	43
Pogonias cromis	14	12	108	10	7	11	12
Cynoscion arenarius	309	123	334	674	219	189	652
Cynoscion nebulosus	19	151	120	90	22	32	30
Cynoscion nothus	———	———	———	1	5	110	1,833
Chaetodipterus faber	———	———	2	2	———	5	14
Prionotus tribulus	———	———	2	7	20	15	59
Gobionellus boleosoma	———	2	———	28	4	14	9
Gobiosoma bosc	9	40	72	48	3	———	1
Sphoeroides marmoratus	1	1	9	29	46	14	24
Chilomycterus schoepfi	———	———	———	———	3	7	16
Citharichthys spilopterus	6	11	2	16	21	3	16
Etropus crossotus	1	———	———	80	23	38	68
Paralichthys lethostigma	32	53	49	56	35	7	9
Achirus fasciatus	3	1	17	5	13	3	56
Achirus lineatus	2	4	18	39	7	28	27
Symphurus plagiusa	———	———	———	11	1	12	232

TABLE 5

The number of hauls made with the different types of nets at the various salinities are given

Salinity	0.0–4.9	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–
Trawls	14	4	26	19	10	8	28
Nets	18	9	35	26	7	11	8
Minnow Seines	17	13	31	33	18	23	34
Beach Seines	—	—	—	—	—	7	13

TABLE 6

The data on the catch of the bonnethead shark, *Sphyrna tiburo*

1941			
Date	April 12	September 16	October 15
Station	Trawl 6	Trawl 7	Trawl 8
Salinity	23.0	36.2	30.6
Temperature	24.0	29.4	28.2
Length	42.4 cm.	30.8 cm.	31.5 cm.
Food	Not opened	Not opened	Not opened

1942				
Date	April 29	August 25		October 16
Station	Trawl 6	Trammel 7		Trammel 8
Salinity	22.8	26.7		23.9
Temperature	24.0	29.2	Foetal young	25.0
Length	52.5 cm.	104.0 cm.	4(31.0 cm.)	87.5 cm.
		105.0 cm.	8(30.0 cm.)	
		106.5 cm.	8(28.5 cm.)	
		112.5 cm.	5(28.0 cm.)	
Food	Empty	14 blue crabs		1 blue crab

TABLE 7

The monthly catches of the stingaree, *Dasyatis sabina*, in the different gear

	1941								1942					
	May	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay															
Trawls	1	—	1	—	3	—	—	—	—	4	2	2	—	—	—
Nets	—	—	—	—	1	—	—	—	—	—	1	2	—	—	2
Aransas Bay															
Trawls	—	1	—	8	8	8	3	—	2	27	16	—	—	2	—
Nets	—	7	3	2	10	2	6	—	—	—	—	1	—	1	2
Minnow Seines	—	—	—	—	—	1	—	—	1	—	1	—	—	—	—
Gulf															
Trawls	—	—	1	—	—	61	—	8	—	7	—	—	—	—	—
Beach Seines	—	2	—	—	4	2	—	2	—	—	—	—	12	—	—
Totals	1	10	5	10	26	74	9	10	3	38	20	5	12	3	4

TABLE 8

The number of *Harengula macropthalma* taken throughout the study in the three bodies of water are given, with the limits of their stay, their size limits and the salinity range of water in which they were caught

	Number	Month Present	Length in Mm.	Salinity Range
Trawls				
Copano	1	September	72	12.7
Aransas	14	September	72–96	21.1–33.7
Gulf	25	April to September	113–168	30.7–36.7
Minnow Seines				
Copano	3	August	54–65	4.8
Aransas	329	June to October	25–72	14.8–36.9
Gulf	1,811	April to November	23–84	28.1–36.7

TABLE 9

Abundance of *Harengula macropthalma* in minnow seine hauls on the Gulf Beach

	June	July	August	September	October	November
Average catch, 1941	26.0	7.0	14.5	84.0	158.0	1.5
Average catch, 1942	None	No data	275.0	338.5	4.5	None

TABLE 10

The monthly catches of the menhaden, *Brevoortia* sp., are shown

	1941										1942					
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.
Copano																
Trawls	51	69	54	3	16	100	31	59	1	3	11	3	1	65	—	3
Nets	—	—	—	—	—	1	—	—	—	—	—	1	2	1	—	—
Minnow Seines	—	—	—	—	—	—	—	—	—	—	90	14	222	81	8	3
Aransas																
Trawls	—	—	24	1	5	15	20	19	62	12	1	9	25	—	—	28
Nets	—	—	4	5	3	—	3	1	—	—	34	28	1	—	—	11
Minnow Seines	—	—	—	—	—	—	—	—	—	—	—	—	72	5	—	—
Totals	51	69	82	9	24	116	54	79	63	15	136	55	323	152	8	45

TABLE 11

The total number of specimens of *Brevoortia* sp. caught in both bays, and the salinity and temperature ranges at stations where the fish were caught

	Minnow Seines		Trawls	
	Copano	Aransas	Copano	Aransas
Number of sp.	418	77	471	223
Size range mm.	21–48	22–33	30–183	40–212
Salinity range	2.0–20.4	17.7–25.0	2.1–18.4	2.1–33.7
T.° C. range	15.5–31.0	23.2–26.7	10.6–30.0	8.1–30.5
	Nets		Total	
	Copano	Aransas	Copano	Aransas
Number of sp.	5	90	894	390
Size range mm.	140–250	163–344	21–250	22–344
Salinity range	12.2–15.6	9.1–24.5	2.0–20.4	2.1–33.7
T.° C. range	14.0–29.5	14.5–30.0	10.6–31.0	8.1–30.5

TABLE 12

The size range and average length in millimeters and the number caught each month are given for the gizzard shad, *Dorosoma cepedianum*, from both Copano and Aransas Bays

1941						
Month	May	June	July	August	September	October
Length range	134–144	72–250	92–135	73–172	105–245	113–235
Average length	139	117	112	130	172	150
Number measured	2	10	22	121	37	66
Number caught	2	10	22	234	37	66

	1941		1942			
Month	November	December	January	February	March	April
Length range	128–285	126–295	119–280	213–255	141–225	128–230
Average length	207	211	236	227	174	161
Number measured	54	33	50	4	5	10
Number caught	56	33	184	4	5	10

1942				
Month	May	June	August	October
Length range	152–245	225–250	88–265	255–280
Average length	220	236	211	269
Number measured	5	5	10	7
Number caught	5	5	13	9

TABLE 13

The number of anchovies, *Anchoa hepsetus*, taken in the different gear each month

	Apr.	June	July	Aug.	Sept.	Oct.	Nov.	Jan.	Apr.	May	June	Aug.
Copano Bay												
Minnow Seines	—	—	1	33	5	—	—	—	—	—	2	—
Aransas Bay												
Minnow Seines	—	—	—	2	26	15	1	—	—	—	—	8
Trawls	1	—	—	—	6	2	—	1	—	—	—	1
Gulf												
Minnow Seines	—	54	177	—	1	741	140	—	2	—	2	—
Beach Seines	—	—	—	—	—	—	6	—	—	—	—	—
Trawls	—	—	21	4	20	—	—	—	5	6	—	—
Totals	1	54	199	39	58	758	147	1	7	6	4	9

TABLE 14

The monthly catches of the bay anchovy, *Anchoa mitchilli diaphana*, in minnow seines and trawls.

	1941											1942						
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay																		
Trawls	----	2	3	58	31	269	236	173	86	23	388	341	40	70	45	----	32	----
Minnow Seines	----	----	----	18	1,585	16	65	191	475	100	4	29	63	109	407	52	5	----
Aransas Bay																		
Trawls	19	166	----	42	39	----	38	56	188	97	274	1,304	423	190	----	2	----	----
Minnow Seines	----	----	----	----	----	163	251	771	87	1	2	184	6	210	114	90	1	----
Gulf																		
Trawls	----	----	----	----	1	----	----	3	----	----	9	----	14	34	3	----	----	----
Minnow Seines	----	----	----	3	28	----	----	14	533	1	77	2	375	249	----	1	----	71
Beach Seines	----	----	----	----	----	----	----	----	2	----	----	----	----	----	----	----	----	----
Totals	19	168	3	121	1,684	448	590	1,208	1,371	222	754	1,860	921	862	569	148	38	71

TABLE 15

The catch of *Bagre marina* for the bays and the Gulf are given for each type of gear, by months. The total average catch each month is also given.

	1941						1942			
	June	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	May	Aug.
Copano Bay										
Trawls	---	6	77	123	43	---	1	---	2	20
Nets	---	1	---	---	---	---	---	1	1	1
Aransas Bay										
Trawls	---	6	42	308	57	---	---	20	---	126
Nets	1	2	---	---	---	---	---	---	---	1
Gulf										
Trawls	---	---	---	---	24	8	---	---	---	---
Nets	---	---	---	---	---	1	---	---	---	---
Totals	1	15	119	431	124	9	1	21	3	148

TABLE 16

The figures are the monthly commercial production of the gaff-topsail catfish on the Texas Coast, given in pounds, for the various years shown. They were taken from the Annual Reports of the Game, Fish and Oyster Commission. The gaff-topsail is practically absent in the winter. The fish catch from the Texas Coast is chiefly from the bays and evidently there is a sharp increase of the catfish in the bays in the spring.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1937	———	———	———	———	———	———	———	———	1,032	———	68	———
1938	———	———	3,136	2,630	771	1,106	310	662	26	247	66	———
1939	197	145	1,718	3,320	1,430	872	97	553	750	2,216	429	———
1940	———	———	1,414	4,224	716	33	163	1,397	1,090	1,011	342	55
1941	31	———	106	4,396	3,232	327	503	613	187	66	528	23
1942	———	———	4,193	2,069	2,698	210	101	417	———	———	———	———
Totals	228	145	10,567	16,639	8,847	2,548	1,174	3,642	3,085	3,540	1,433	78
Ave.	46	29	2,113	3,328	1,769	510	235	728	615	708	287	16

TABLE 17

The numbers of hardhead catfish, *Galeichthys felis*, caught with the different gear in the bays and Gulf are given by months. The spring and fall are times of greatest abundance. In the fall the young came into the catch. The fish was least common in the winter and during January was entirely absent from the bays.

1941	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Copano Bay										
Trawls	---	21	44	5	3	30	52	63	37	3
Minnow Seines	---	---	---	---	---	2	1	---	---	---
Nets	---	---	---	4	2	1	1	6	---	---
Aransas Bay										
Trawls	1	3	---	29	45	74	117	259	93	49
Minnow Seines	---	---	---	---	---	---	---	8	---	---
Nets	---	---	---	66	29	2	1	4	1	---
Gulf										
Trawls	---	---	---	---	---	24	7	1	670	---
Minnow Seines	---	---	---	2	---	---	---	---	---	---
Nets	---	---	---	---	1	---	---	---	---	---
Totals	1	24	44	106	80	133	179	341	801	52

1942	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay								
Trawls	---	4	129	167	228	---	153	---
Minnow Seines	---	---	1	4	---	2	---	---
Nets	---	---	7	14	9	11	16	4
Aransas Bay								
Trawls	---	89	360	140	---	---	53	---
Minnow Seines	---	---	---	---	1	---	---	---
Nets	---	---	6	6	9	26	16	6
Gulf								
Trawls	---	---	1	4	1	---	---	---
Minnow Seines	11	1	4	---	---	---	---	---
Nets	1	---	16	---	---	---	---	---
Totals	12	94	524	335	248	39	238	10

TABLE 18

Data is given on the eggs and young carried by the males of *Galeichthys felis*. Under eggs F. means fresh, W. D. represents well developed, and Ad. means advanced.
The lengths are in mm.

Date	Length, Male	Number Eggs, Stage	Number Young, Length	Locality
1941				
June 17	285	6		Lower Aransas Bay
June 17	285	25 24 W. D., 1. F.		Lower Aransas Bay
June 17	290	33 W. D.		Lower Aransas Bay
June 17	285	3 W. D.		Lower Aransas Bay
June 17	280	26 F.		Lower Aransas Bay
July 11	250	25 W. D.		Lower Aransas Bay
July 11	256		7, 55 mm. (no yolk)	Lower Aransas Bay
July 11	243		12, 55 mm. (no yolk)	Lower Aransas Bay
July 11	201		10, hatching	Lower Aransas Bay
July 11	287	18 Ad.		Middle Aransas Bay
July 11	250		8, small	Middle Aransas Bay
July 11	245	12 F.		Middle Aransas Bay
July 11	251	15 F.		Middle Aransas Bay
July 11	240		3, small	Middle Aransas Bay
July 11	232		3, small	Middle Aransas Bay
July 12	271	25 Ad.		Lower Copano Bay
Aug. 7	231		6, 51–52 mm., little yolk	Lower Aransas Bay
Aug. 7	250		1, 49 mm., small yolk	Lower Aransas Bay
Aug. 7	239		1, 55 mm., no yolk	Lower Aransas Bay
Aug. 7	211		15, 51 mm., no yolk	Lower Aransas Bay
1942				
June 10	275	33		Lower Copano Bay
June 24	280	24		Lower Aransas Bay
June 24	275	22		Lower Aransas Bay
June 24	265	3		Lower Aransas Bay
June 24	320	20		Lower Aransas Bay
June 24	285	5		Lower Aransas Bay
June 24	285	1		Lower Aransas Bay
June 24	305		5, Early Stage	Lower Aransas Bay
June 24	275	11		Lower Aransas Bay
Aug. 4	211		2, 53–55 mm.	Middle Copano Bay
Aug. 5	213		11, 38 mm.	Lower Copano Bay
Aug. 5	245		1, 50 mm.	Upper Copano Bay
Aug. 5	265		6, 55 mm.	Upper Copano Bay

TABLE 19

The monthly catches by bays and the monthly average catches for both bays combined are given for *Lucania parva venusta*. All specimens were taken in minnow seines.

	1941					1942					
	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May	June	Aug.
Copano Bay	16	29	23	17	99	175	30	8	1	4	1
Aransas Bay	27	—	5	11	6	11	2	10	—	1	—
Totals	43	29	28	28	105	186	32	18	1	5	1

TABLE 20

The monthly catches of *Fundulus grandis* are given. All fish were taken in minnow seines. There was a peak of abundance in summer and again in midwinter.

	1941							1942					
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.
Copano Bay	3	27	4	6	1	4	10	55	2	14	4	2	35	29
Aransas Bay	130	14	1	2	—	9	2	7	55	12	6	—	20	—
Totals	133	41	5	8	1	13	12	62	57	26	10	2	55	29

TABLE 21

The number of *Fundulus similis* caught in both bays and the Gulf are given for each month. All fish were taken in minnow seines.

	1941							1942							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Nov.
Copano Bay	5	76	16	6	5	4	7	10	1	4	8	5	—	58	—
Aransas Bay	70	92	—	134	—	16	109	11	141	84	27	36	338	36	—
Gulf Beach	—	—	—	—	—	—	—	—	1	1	—	—	—	—	1
Totals	75	168	16	140	5	20	116	21	143	89	35	41	338	94	1

TABLE 22

The monthly catches of *Cyprinodon variegatus variegatus* in Copano and Aransas Bays in minnow seines are given. One fish was caught in a trawl in Lydia Ann Channel in January, 1942.

	1941							1942					
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May	June	Aug.
Copano Bay	43	184	17	20	—	3	613	1,627	58	66	1	137	236
Aransas Bay	429	661	1	185	3	107	356	174	1,682	41	2	24	2
Totals	472	845	18	205	3	110	969	1,801	1,740	107	3	161	238

TABLE 23

The monthly catches and size range of *Urophycis floridanus* are shown. All fish were caught in trawls. Lengths are in mm.

	1942			
	Feb.	Mar.	Apr.	May
Copano Bay				1
Aransas Bay	7	22	5	----
Gulf of Mexico	----	9	5	1
Total	7	31	10	2
Length range	82–118	71–187	99–173	133–203

TABLE 24

The monthly catches of *Menidia beryllina peninsulae*, the Gulf silverside, for the bays and the Gulf are shown. All fish caught in Copano Bay and the Gulf of Mexico were taken in minnow seines.

	1941							1942							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Nov.
Copano Bay	———	519	110	138	61	341	24	128	223	124	43	29	63	950	———
Aransas Bay															
Minnow Seines	2,289	337	287	526	76	555	244	334	199	244	47	222	1,022	864	———
Trawls	———	———	———	———	———	———	———	6	1	———	———	———	———	———	———
Gulf	4	32	———	———	———	1	———	3	1	1	———	———	———	———	6
Totals	2,293	888	397	664	137	897	268	471	424	369	90	251	1,085	1,814	6

TABLE 25

The monthly catches of the rough silverside, *Membras vagrans vagrans*, are shown. All fish were taken in minnow seines.

	1941						1942					
	June	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay	—	5	110	6	9	6	—	1	14	8	128	—
Aransas Bay	19	47	—	5	83	2	2	—	11	26	1	—
Gulf	2	35	7	—	6	108	6	3	—	1	49	10
Totals	21	86	117	11	98	116	8	4	25	35	178	10

TABLE 26

The number of striped mullet, *Mugil cephalus*, taken each month in the different gear are shown.

	1941							1942									
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Sept.	Oct.	Nov.
Copano Bay																	
Minnow Seines	—	17	—	8	1	—	1	10	55	23	26	3	13	2	—	—	—
Trawls	—	—	30	—	1	7	—	—	2	—	1	—	—	—	—	—	—
Nets	33	9	7	—	—	27	44	23	25	2	—	1	—	2	—	50	—
Aransas Bay																	
Minnow Seines	146	37	2	11	—	35	—	2,325	989	148	40	27	28	86	—	—	—
Trawls	—	—	55	4	3	—	—	—	—	—	—	—	—	3	—	—	—
Nets	2	1	2	—	1	9	20	36	7	2	—	1	—	2	—	32	—
Gulf																	
Minnow Seines	1	—	—	—	—	—	4	14	218	256	10	—	1	—	—	1	21
Nets	—	—	—	—	1	3	4	4	4	11	—	—	5	—	4	—	—
Totals	182	64	96	23	7	81	72	2,412	1,300	442	77	32	47	95	4	83	21

TABLE 27

The monthly catches of the white mullet, *Mugil curema*, in the various gear are shown.

	1941						1942				
	June	July	Aug.	Sept.	Oct.	Dec.	May	June	Aug.	Oct.	Nov.
Copano Bay											
Minnow Seines	—	11	—	2	—	—	—	—	4	—	—
Nets	—	—	—	—	—	1	—	—	—	—	—
Aransas Bay											
Minnow Seines	81	82	4	6	—	—	12	166	36	—	—
Trawls	—	—	3	22	—	—	—	—	1	—	—
Gulf											
Minnow Seines	152	10	1	—	1	—	—	12	6	5	1
Totals	233	103	8	30	1	1	12	178	47	5	1

TABLE 28

The monthly catches of the threadfin, *Polydactylus octonemus*, in the various gear and bodies of water are given.

	1941								1942				
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Apr.	May	June	Aug.	Oct.
Copano Bay													
Trawls	—	3	5	52	14	2	8	—	—	55	—	68	—
Nets	—	—	—	—	—	—	—	—	—	—	1	—	—
Aransas Bay													
Trawls	1	—	311	61	20	57	61	—	80	—	—	58	—
Minnow Seines	—	—	13	—	—	—	—	—	15	—	—	—	—
Gulf													
Trawls	—	—	68	93	116	53	36	4	23	135	—	—	—
Minnow Seines	—	—	53	145	411	2	—	—	32	—	255	1	1
Nets	—	—	—	22	—	—	—	—	—	—	—	—	—
Totals	1	3	450	375	561	114	105	4	150	190	256	127	1

TABLE 29

The monthly production of Spanish mackerel on the Texas Coast for the years shown is given. The figures are in pounds and are compiled from statistics of the Game, Fish and Oyster Commission.

	Sept.	Oct.	Nov.	Dec.
1937–38	------	446	------	------
1938–39	1,637	666	------	------
1939–40	2,505	95	347	17
1940–41	925	727	89	165
1941–42	------	30	------	------
Totals	5,067	1,964	436	182
Monthly Average	1,013	393	87	36

	Jan.	Mar.	Apr.	May	June	July	Aug.
1937–38	------	374	5,681	194	215	3,548	741
1938–39	------	97	354	3,237	1,383	158	22,246
1939–40	------	------	392	448	226	1,470	1,257
1940–41	37	------	1,231	490	386	2,839	9,499
1941–42	------	------	6,213	3,349	4,035	2,556	2,749
Totals	37	471	13,871	7,718	6,245	10,571	36,492
Monthly Average	7	94	2,774	1,546	1,249	2,114	7,298

TABLE 30

The monthly catches of the moonfish, *Vomer setapinnis*, are given.

	1941						1942			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mar.	Apr.	May	June
Aransas Bay										
Trawls	---	2	6	1	1	1	1	---	---	---
Gulf										
Trawls	29	226	18	2	3	---	---	9	4	---
Beach Seines	---	---	---	1	1	---	---	---	---	1
Totals	29	228	24	4	5	1	1	9	4	1

TABLE 31

The monthly catches of the bumper or yellowtail, *Chloroscombrus chrysurus*, are given.

	1941				1942	
	July	Aug.	Sept.	Oct.	June	Aug.
Aransas Bay						
Trawls	---	53	2	11	---	1
Gulf						
Trawls	---	29	17	---	---	---
Beach Seines	---	---	---	8	14	---
Totals	9	82	19	19	14	1

TABLE 32

The monthly catches of the common pompano, *Trachinotus carolinus*, are given.

	1941							1942				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	June	Aug.	Sept.	Oct.	Nov.
Gulf												
Minnow Seines	38	128	26	49	39	7	2	44	21	154	14	13
Beach Seines	—	5	—	—	—	—	—	1	8	7	—	—
Totals	38	133	26	49	39	7	2	45	29	161	14	13

TABLE 33

The monthly catches of the pigfish, *Orthopristes chrysopterus*, are given.

	1941							1942					
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	June	Aug.
Aransas Bay													
Trawls	—	13	—	12	29	15	10	—	3	86	24	—	14
Minnow Seines	3	—	—	—	—	—	—	—	—	—	—	7	1
Nets	—	—	—	1	—	—	3	—	—	—	—	1	1
Gulf													
Trawls	—	1	3	2	—	39	—	17	—	5	—	—	—
Totals	3	14	3	15	29	54	13	17	3	91	24	8	16

TABLE 34

The monthly catches of the pinfish, *Lagodon rhomboides*, are given.

	1941									1942							
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay																	
Trawls	—	76	2	—	—	—	1	3	—	—	—	4	—	1	—	—	—
Minnow Seines	—	—	27	28	1	1	2	—	—	—	1	1	1	2	32	5	—
Nets	—	—	1	4	3	2	1	—	—	—	—	—	—	—	1	23	30
Aransas Bay																	
Trawls	6	—	1	17	13	127	4	38	1	3	—	—	—	—	—	76	—
Minnow Seines	—	—	64	44	18	17	8	1	—	8	6	8	14	60	17	25	—
Nets	—	—	2	3	4	2	20	2	—	—	—	—	1	1	2	10	7
Gulf																	
Trawls	—	—	—	—	—	—	—	11	—	13	—	—	—	—	—	—	—
Totals	6	76	97	96	39	149	36	55	1	24	7	13	16	64	52	139	37

TABLE 35

The monthly catches of the yellowtail, *Bairdiella chrysura*, are given.

	1941									1942			
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
Copano Bay													
Trawls	—	5	8	20	—	11	—	—	1	—	2	2	—
Minnow Seines	—	—	1	—	—	—	—	—	—	—	—	—	—
Aransas Bay													
Trawls	7	—	2	1	1	25	1	60	4	—	2	1	26
Minnow Seines	—	—	10	20	—	1	2	—	—	—	—	—	—
Gulf													
Trawls	—	—	—	—	—	—	—	2	—	20	—	—	—
Minnow Seines	—	—	—	—	—	—	—	—	—	1	—	—	—
Totals	7	5	21	41	1	37	3	62	5	21	4	3	26

TABLE 36

The size limits of yellowtails, *B. chrysura*, caught in the various months are shown.

	1941								
Month	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Length, mm.	112–156	115–144	16–162	15–150	124	48–162	66–121	91–156	83–140

	1942			
Month	Jan.	Mar.	Apr.	Aug.
Length, mm.	98–168	123–164	138–148	73–104

TABLE 37

The monthly catches of the star drum, *Stellifer lanceolatus*, are given. All fish were taken in trawls.

	1941							1942			
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	Aug.
Copano Bay	---	---	---	1	1	2	2	---	---	---	---
Aransas Bay	---	4	---	1	24	11	50	---	12	3	1
Gulf	43	1	1	---	26	47	---	25	77	69	---
Totals	43	5	1	2	51	60	52	25	89	72	

TABLE 38

The monthly catches of the redfish, *Sciaenops ocellata*, in the various gear are shown.

	1941							1942							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay															
Minnow Seines	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—
Nets	3	8	25	—	2	37	41	13	13	1	1	2	6	15	60
Aransas Bay															
Minnow Seines	—	—	—	—	15	10	—	2	1	—	3	1	—	—	—
Nets	4	5	4	2	4	8	11	3	2	2	—	1	—	8	33
Trawls	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
Gulf															
Beach Seines	—	—	—	—	3	1	—	1	—	—	—	—	—	—	—
Totals	7	13	30	2	24	56	52	21	16	3	5	4	6	23	93

TABLE 39

The number of redfish, *Sciaenops ocellata*, of the various sizes taken each month are shown. The figures are in centimeters and the fish taken within any 2.5 cm. group are thrown together. The smallest fish were taken in minnow seines.

1941	1.5	4.0	6.5	9.0	11.5	14.0	16.5	19.0	21.5	24.0	26.5	29.0	31.5	34.0	36.5	39.0
June	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
July	—	—	—	—	—	—	—	—	—	1	2	3	1	3	—	—
Aug.	—	—	—	—	—	—	—	—	—	—	4	12	8	4	—	—
Sept.	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—
Oct.	1	10	4	—	—	—	—	—	—	—	—	—	—	—	3	3
Nov.	9	1	—	—	—	—	—	—	—	—	—	—	—	1	5	18
Dec.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	6	16
1942																
Jan.	—	2	1	1	—	—	—	—	—	—	—	—	—	1	4	1
Feb.	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	1
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Apr.	—	—	—	1	1	2	—	—	—	—	—	—	—	—	—	—
May	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	—	—	—	—	3	13	2	2	—	—
Oct.	—	—	—	—	—	—	—	—	—	—	5	13	24	16	—	2

TABLE 39—Continued

The number of redfish, *Sciaenops ocellata*, of the various sizes taken each month are shown. The figures are in centimeters and the fish taken within any 2.5 cm. group are thrown together. The smallest fish were taken in minnow seines.

1941	41.5	44.0	46.5	49.0	51.5	54.0	56.5	59.0	61.5	64.0	66.5	69.0	71.5	74.0	76.5	79.0	81.5	84.0
June	—	—	—	—	2	1	3	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—
Sept.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct.	2	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Nov.	8	4	2	2	—	1	—	—	—	1	—	3	—	1	—	—	—	—
Dec.	7	7	3	—	2	1	—	—	—	2	1	2	2	1	—	—	—	1
1942																		
Jan.	3	2	2	1	—	1	—	—	—	—	—	1	1	—	—	—	—	—
Feb.	5	7	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Apr.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
May	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	1	1	2	1	—	—	—	—	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
Oct.	2	—	—	—	—	1	2	3	6	5	2	—	3	—	—	—	—	—

TABLE 40

The monthly catches of the flat croaker, *Leiostomus xanthurus*, taken in different gear are given.

	1941										1942							
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay																		
Trawls	—	8	28	38	1	1	1	1	3	1	—	6	1	4	19	—	—	—
Minnow Seines	—	—	—	—	2	—	—	—	—	—	—	—	—	9	7	—	2	—
Nets	—	—	—	—	—	—	5	1	—	—	—	3	—	—	3	—	1	2
Aransas Bay																		
Trawls	39	68	—	53	16	61	38	50	20	2	5	3	84	77	—	—	169	—
Minnow Seines	—	—	—	—	2	—	—	1	—	—	—	—	—	49	19	6	2	—
Nets	—	—	—	54	2	—	2	4	—	2	—	1	—	—	1	3	2	6
Gulf																		
Trawls	—	—	—	25	2	38	6	4	2	—	142	—	1	4	—	—	—	—
Minnow Seines	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Beach Seines	—	—	—	—	—	—	—	—	—	—	19	4	1	—	—	—	—	—
Totals	39	76	28	170	25	100	52	67	47	5	166	17	87	143	49	9	176	8

TABLE 41

The monthly catches of the croaker, *Micropogon undulatus*, in the different gear are given.

	1941									
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Copano Bay										
Trawls	____	429	1,770	1,220	897	307	359	23	2	____
Minnow Seines	____	____	____	____	4	2	____	____	____	____
Nets	____	____	____	____	____	3	____	____	____	____
Aransas Bay										
Trawls	18	5	____	1,289	608	545	806	48	24	36
Minnow Seines	____	____	____	____	____	____	____	____	7	2
Nets	____	____	____	____	4	____	6	____	____	1
Gulf										
Trawls	____	____	____	54	49	744	57	54	46	____
Beach Seines	____	____	____	____	____	____	____	1	6	2
Totals	18	434	1,770	2,563	1,562	1,601	1,228	126	85	54

	1942							
	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay								
Trawls	39	373	889	1,497	1,086	____	144	____
Minnow Seines	3	83	12	11	4	____	____	____
Nets	2	____	____	____	8	3	31	____
Aransas Bay								
Trawls	37	92	506	1,028	____	____	193	36
Minnow Seines	1	119	41	2	____	____	____	____
Nets	____	____	____	____	____	20	7	____
Gulf								
Trawls	111	____	2	2	26	____	____	____
Minnow Seines	____	____	1	____	____	5	____	____
Beach Seines	____	____	1	____	____	1	____	____
Totals	193	667	1,452	2,540	1,124	29	375	36

TABLE 42

The monthly catches of the shoemaker or whiting, *Menticirrhus americanus*, are given.

	1941							1942						
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	June	Aug.	Nov.
Aransas Bay														
Trawls	—	5	—	14	37	7	19	—	1	27	16	—	3	—
Minnow Seines	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Nets	—	—	1	—	—	2	—	—	—	—	—	—	—	—
Gulf														
Trawls	3	1	26	6	13	29	—	32	—	62	9	—	—	—
Minnow Seines	—	8	1	—	—	—	—	—	—	—	—	1	—	1
Totals	3	15	28	20	50	38	19	32	1	89	25	1	3	1

TABLE 43

The size limits of the American whiting or shoemaker, *Menticirrhus americanus*, taken in Aransas Bay and the Gulf of Mexico at various months are given in millimeters.

	1941						
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Aransas Bay		94–221	310	165–273	139–278	114–280	92–269
Gulf of Mexico	144–158	32–177	24–273	158–280	150–255	144–243	

	1942						
	Jan.	Feb.	Mar.	Apr.	June	Aug.	Nov.
Aransas Bay		244	122–270	117–318		182–194	
Gulf of Mexico	92–294		158–285	172–228	40		38

TABLE 44

The monthly catches of the black drum, *Pogonias cromis*, are given.

	1941							1942							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay															
Nets	11	1	5	1	10	21	31	21	12	3	—	1	—	4	3
Aransas Bay															
Nets	6	5	1	1	—	3	3	—	—	—	1	—	1	3	8
Minnow Seines	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—
Gulf															
Beach Seines	—	—	—	—	7	3	1	1	1	—	1	—	—	1	—
Totals	17	6	6	2	17	27	35	22	13	3	2	1	4	8	11

TABLE 45

The monthly catches of the sand trout, *Cynoscion arenarius*, in the various gear are shown.

	1941										1942							
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay																		
Trawls	—	—	8	59	151	70	265	83	37	3	—	—	2	—	16	—	1	—
Minnow Seines	—	—	—	—	—	—	3	—	—	—	—	—	—	—	1	—	—	—
Aransas Bay																		
Trawls	1	1	—	71	259	13	305	297	282	39	—	5	68	62	—	—	50	—
Minnow Seines	—	—	—	—	—	—	—	1	1	—	—	—	—	—	2	3	—	—
Nets	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
Gulf																		
Trawls	—	—	—	5	16	23	27	84	56	—	109	—	11	4	—	—	—	—
Minnow Seines	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
Beach Seines	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Totals	1	1	8	135	426	106	600	466	380	42	109	5	81	66	19	3	51	1

TABLE 46

The average lengths in mm. of sand trout, *Cynoscion arenarius*, taken at various salinities are shown.

Salinity	0.0–4.9	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0———
Average length	75.2	106.3	127.8	119.4	123.8	122.6	150.5
Number measured	309	123	182	340	181	96	393

TABLE 47

The monthly catches of the speckled trout, *Cynoscion nebulosus*, are shown.

	1941							1942							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay															
Trawls	1	—	—	—	—	—	—	1	7	3	3	9	—	1	—
Nets	—	2	—	2	3	13	15	12	14	5	2	14	2	5	6
Minnow Seines	—	—	—	—	7	6	1	—	1	—	—	—	6	—	—
Aransas Bay															
Trawls	—	—	—	—	—	2	6	13	4	4	1	—	—	2	—
Nets	126	—	1	—	—	3	2	12	6	8	4	8	14	9	33
Minnow Seines	—	8	—	11	5	12	—	—	—	—	—	—	3	1	—
Gulf															
Trawls	—	—	—	—	—	—	—	14	—	—	—	—	—	—	—
Beach Seines	—	—	—	—	2	7	—	—	—	—	—	—	—	1	—
Minnow Seines	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Totals	127	10	1	13	17	44	24	52	32	20	10	31	25	19	39

TABLE 48

The monthly catches of the sand trout, *Cynoscion nothus*, are shown.

	1941							1942				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	May	June
Aransas Bay												
Trawls	—	—	—	—	1	—	50	—	108	34	—	—
Gulf												
Trawls	12	40	65	42	30	94	—	43	649	557	216	—
Minnow Seines	—	—	—	—	—	—	—	—	—	—	—	8
Totals	12	40	65	42	31	94	50	43	757	591	216	8

TABLE 49

The monthly catches of the common sea robin, *Prionotus tribulus*, are shown. All catches were in trawls.

	1941							1942			
	Mar.	Apr.	June	Aug.	Sept.	Oct.	Nov.	Jan.	Mar.	Apr.	May
Copano Bay	—	—	—	—	—	—	—	—	1	—	—
Aransas Bay	1	1	—	1	—	5	—	—	15	9	—
Gulf	—	—	3	—	9	9	5	13	5	4	22
Totals	1	1	3	1	9	14	5	13	21	13	22

TABLE 50

The monthly catches of *Gobiosoma bosc* are given.

	1941						1942						
	June	July	Aug.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.
Copano Bay													
Minnow Seines	3	—	—	13	27	19	7	9	1	8	6	12	—
Aransas Bay													
Minnow Seines	4	2	—	6	28	2	3	—	—	1	—	18	2
Trawls	—	—	1	—	—	—	—	—	—	1	—	—	—
Totals	7	2	1	19	55	21	10	9	1	10	6	30	2

TABLE 51

The monthly catches of the puffer, *Sphoeroides marmoratus*, are given.

	1941								1942					
	Mar.	Apr.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Copano Bay														
Trawls	—	1	1	1	—	1	—	2	—	—	—	—	—	—
Minnow Seines	—	—	—	—	—	—	1	—	—	—	—	—	10	3
Aransas Bay														
Trawls	3	—	4	—	7	5	26	9	2	2	5	—	—	—
Minnow Seines	—	—	—	—	—	1	—	—	—	—	—	1	14	9
Gulf														
Trawls	—	—	1	—	—	1	12	—	—	—	1	1	—	—
Totals	3	1	6	1	7	8	39	11	2	2	6	2	24	12

TABLE 52

The monthly catches of *Citharichthys spilopterus* are shown.

	1941							1942			
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mar.	Apr.	May	Aug.
Copano Bay											
Trawls	1	2	9	3	—	—	—	—	—	3	4
Aransas Bay											
Trawls	—	2	—	8	7	—	4	—	14	—	—
Minnow Seines	—	—	—	—	—	1	—	—	4	—	—
Gulf											
Trawls	—	—	4	1	—	1	—	3	—	4	—
Totals	1	4	13	12	7	2	4	3	18	7	4

TABLE 53

The monthly catches of *Etropus crossotus* are shown.

	1941						1942					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Aug.
Copano Bay												
Trawls	1	—	—	—	—	—	—	—	—	—	—	—
Aransas Bay												
Trawls	1	—	2	45	6	30	—	2	3	18	—	5
Minnow Seines	—	—	—	—	1	—	—	—	—	—	—	—
Gulf												
Trawls	1	13	3	—	15	—	39	—	18	2	5	—
Totals	3	13	5	45	22	30	39	2	21	20	5	5

TABLE 54

The monthly catches of southern flounder, *Paralichthys lethostigma,* are shown.

	1941									1942							
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano Bay																	
Trawls	1	4	—	5	35	8	5	2	1	1	15	5	11	23	—	21	—
Nets	—	—	—	1	—	2	—	—	—	—	1	2	1	—	—	1	6
Minnow Seines	—	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—	—
Aransas Bay																	
Trawls	1	—	1	3	—	6	8	3	2	1	2	3	15	—	—	13	—
Nets	—	—	—	—	—	—	1	1	1	—	—	—	—	—	3	2	3
Minnow Seines	—	—	—	—	—	—	—	—	1	—	7	1	3	—	—	—	—
Gulf																	
Trawls	—	—	—	—	—	—	—	—	—	—	—	3	2	—	—	—	—
Totals	2	4	1	9	35	16	14	6	5	2	25	15	35	23	3	37	9

TABLE 55

The monthly catches of the American broad sole, *Achirus fasciatus*, are given.

	1941							1942			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.	May	Aug.
Copano Bay											
Trawls	2	1	—	2	—	6	—	2	6	—	1
Nets	—	—	—	—	—	—	—	1	—	—	—
Aransas Bay											
Trawls	9	—	3	2	3	—	—	1	3	—	—
Nets	—	—	—	—	—	1	—	—	—	1	—
Gulf											
Trawls	—	—	—	—	53	—	1	—	—	—	—
Totals	11	1	3	4	56	7	1	4	9	1	1

TABLE 56

The monthly catches of the lined sole, *Achirus lineatus*, are shown.

	1941							1942				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Copano Bay												
Trawls	1	1	3	2	1	3	1	1	4	6	1	—
Aransas Bay												
Trawls	—	6	—	4	34	1	1	—	2	—	24	—
Minnow Seines	—	2	—	—	—	2	—	—	—	—	—	—
Gulf												
Trawls	3	2	—	—	1	—	—	4	—	6	3	6
Totals	4	11	3	6	36	6	2	5	6	12	28	6

TABLE 57

The monthly catches of the tonguefish, *Symphurus plagiusa*, are given.

	1941					1942			
	July	Aug.	Sept.	Nov.	Dec.	Jan.	Mar.	Apr.	May
Aransas Bay									
Trawls	---	---	---	---	4	---	---	---	---
Minnow Seines	---	---	---	4	2	1	---	1	---
Gulf									
Trawls	1	1	2	17	---	32	185	5	1
Totals	1	1	2	21	6	33	185	6	1

TABLE 58

The total numbers and average catch of fishes made during this study in the bays and Gulf of Mexico with the different types of gear are given.

	Bays	Average per Haul	Gulf	Average per Haul	Totals
Trammel Nets and Beach Seines	2,283	20.0	264	11.5	2,547
Trawls	29,276	332.7	7,208	343.2	36,484
Minnow Seines	31,910	236.4	7,324	209.3	39,234
Totals	63,469	.....	14,796	.....	78,265

TABLE 59

This lists the fishes taken less than 100 times in this work, divided into categories according to numbers, as is explained in the subheadings.

Fishes Caught 1 Time

Isogomphodon limbatus
Hypoprion brevirostris
Mollienisia latipinna
Hippocampus regulus
Sphyraena guachancho
Trachinotus palometa
Lobotes surinamensis
Lutianus griseus
Conodon nobilis
Scorpaena ginsburgi
Prionotus beanii
Rissola marginata
Gobiesox strumosus
Balistes capriscus

Fishes Caught 2 to 4 Times

Raja texana
Pteroplatea micrura
Tarpon atlanticus
Pomolobus chrysochloris
Opisthonema oglinum
Hyporhamphus unifasciatus
Syngnathus louisianae
Syngnathus mackayi
Scomberomorus maculatus
Pomatomus saltatrix
Larimus fasciatus
Prionotus pectoralis
Gobionellus hastatus
Lepophidium brevibarbe
Otophidium welshi
Opsanus beta
Lactophrys tricornis
Citharichthys macrops

Fishes Caught 5 to 10 Times

Sphyrna tiburo
Dasyatis americana
Anchoa lyolepis
Peprilus paru
Hemicaranx rhomboides
Selene vomer
Oligoplites saurus
Centropristes philadelphicus
Upeneus martinicus
Prionotus punctatus
Astroscoups y-graecum
Opsanus sp.
Nautopaedium porossissimum
Ogcocephalus vespertilio
Ancylopsetta quadrocellata

Fishes Caught 11 to 25 Times

Narcine brasiliensus
Lepisosteus spathula
Elops saurus
Brevoortia tyrannus
Strongylura marina
Archosargus probatocephalus
Chaetodipterus faber
Ogcocephalus nasutus
Paralichthys albigutta

Fishes Caught 26 to 50 times

Synodus foetens
Adinia multifasciata
Urophycis floridanus
Trachurus lathami
Caranx hippos
Gerres rhombeus
Prionotus scitulus
Everthodes lyricus
Chilomycterus schoepfi

Fishes Caught 51 to 100 Times

Trichiurus lepturus
Menticirrhus littoralis
Gobionellus boleosoma
Citharichthys spilopterus
Achirus fasciatus

TABLE 60

The total numbers of fishes caught in both the bays and the Gulf are given for all species taken over 100 times.

Species	Bays	Gulf	Totals
Micropogon undulatus	14,695	1,162	15,857
Anchoa mitchilli diaphana	9,634	1,420	11,054
Menidia beryllina peninsulae	10,006	48	10,054
Cyprinodon variegatus variegatus	6,673	———	6,673
Mugil cephalus	4,474	562	5,040
Galeichthys felis	2,531	744	3,275
Harengula macropthalma	347	2,168	2,515
Cynoscion arenarius	2,161	339	2,500
Polydactylus octonemus	559	1,778	2,337
Cynoscion nothus	193	1,756	1,949
Fundulus similis	1,359	3	1,362
Brevoortia sp.	1,284	142	1,426
Anchoa hepsetus	104	1,179	1,283
Leiostomus xanthurus	988	276	1,264
Lagodon rhomboides	883	24	907
Bagre marina	839	33	872
Membras vagrans vagrans	483	227	710
Dorosoma cepedianum	692	———	692
Mugil curema	431	188	619
Trachinotus carolinus	———	556	556
Luciania parva venusta	476	———	476
Cynoscion nebulosus	439	25	464
Fundulus grandis	454	———	454
Eucinostomus spp.	435	9	444
Stellifer lanceolatus	112	289	401
Sciaenops ocellata	352	5	357
Menticirrhus americanus	133	192	325
Vomer setapinnis	12	294	306
Orthopristes chrysopterus	223	67	290
Symphurus plagiusa	12	244	256
Dasyatis sabina	146	99	245
Paralichthys lethostigma	236	5	241
Bairdiella chrysura	213	23	236
Signalosa mexicana	229	———	229
Etropus crossotus	114	96	210
Syacium gunteri	———	192	192
Pogonias cromis	159	15	174
Gobiosoma bosc	173	———	173
Syngnathus scovelli	150	———	150
Chloroscombrus chrysurus	67	77	144
Achirus lineatus	100	25	125
Sphoeroides marmoratus	108	16	124
Prionotus tribulus	33	70	103

TABLE 61

The order of abundance of the twenty-six fishes most often taken in trawl hauls in Louisiana and Texas are given for comparison. For full explanation, see text.

Bays	
Louisiana	Texas
Micropogon undulatus	Micropogon undulatus
Anchoviella epsetus (largely A. m. diaphana)	Anchoa mitchilli diaphana
Brevoortia patronus (Brevoortia sp.)	Galeichthys felis
Cynoscion arenarus	Cynoscion arenarius
Galeichthys felis	Bagre marina
Polydactylus octonemus	Leiostomus xanthurus
Stellifer lanceolatus	Brevoortia sp.
Leiostomus xanthurus	Polydactylus octonemus
Achirus fasciatus	Dorosoma cepedianum
Bagre marina	Lagodon rhomboides
Bairdiella chrysura	Signalosa mexicana
Vomer setapinnis	Orthopristes chrysopterus
Etropus crossotus	Paralichthys lethostigma
Cynoscion nebulosus	Cynoscion nothus
Citharichthys spilopterus	Bairdiella chrysura
Poronotus triacanthus	Menticirrhus americanus
Achirus lineatus	Etropus crossotus
Signalosa mexicana	Stellifer lanceolatus
Symphurus plagiusa	Mugil cephalus
Paralichthys lethostigma	Achirus lineatus
Sphoeroides marmoratus	Dasyatis sabina
Menticirrhus americanus	Sphoeroides marmoratus
Trichiurus lepturus	Chloroscombrus chrysurus
Chaetodipterus faber	Trichiurus lepturus
Cynoscion nothus	Cynoscion nebulosus
Larimus fasciatus	Citharichthys spilopterus

Gulf	
Louisiana	Texas
Micropogon undulatus	Cynoscion nothus
Stellifer lanceolatus	Micropogon undulatus
Cynoscion arenarius	Polydactylus octonemus
Anchoviella epsetus (mixed, see above)	Galeichthys felis
Vomer setapinnis	Cynoscion arenarius
Leiostomus xanthurus	Vomer setapinnis
Galeichthys felis	Stellifer lanceolatus
Cynoscion nothus	Symphurus plagiusa
Trichiurus lepturus	Leiostomus xanthurus
Menticirrhus americanus	Syacium gunteri
Polydactylus octonemus	Menticirrhus americanus
Poronotus triacanthus	Etropus crossotus
Achirus fasciatus	Dasyatis sabina
Bagre marina	Orthopristes chrysopterus
Etropus crossotus	Anchoa mitchilli diaphana
Citharichthys spilopterus	Anchoa hepsetus
Symphurus plagiusa	Chloroscombrus chrysurus
Larimus fasciatus	Achirus fasciatus
Bairdiella chrysura	Bagre marina
Chaetodipterus faber	Poronotus triacanthus
Achirus lineatus	Trachurus lathami
Signalosa mexicana	Gerres rhomboides
Sphoerodes marmoratus	Harengula macropthalma
Paralichthys lethostigma	Achirus lineatus
Cynoscion nebulosus	Lagodon rhomboides
Harengula macropthalma	Trichiurus lepturus

TABLE 62

The numbers of fishes belonging to the most numerous families caught in trawls in Louisiana and Texas are shown for comparison of their relative abundance. Over 144,000 fishes were caught in Louisiana while 36,484 were taken in Texas.

Louisiana		Texas	
Family	Number	Family	Number
Sciaenidae	90,418	Sciaenidae	17,371
Otolithidae	12,940	Engraulidae	4,766
Engraulidae	10,961	Otolithidae	4,495
Ariidae	7,234	Ariidae	3,836
Clupeidae	6,253	Polynemidae	1,386
Heterosomata	5,959	Clupeidae	1,382
Carangidae	3,500	Heterosomata	1,154
Polynemidae	3,219	Carangidae	468
Trichiuridae	1,510	Sparidae	397
Stromateidae	1,362	Haemulidae	273
Triglidae	499	Dasyatidae	173
Tetraodontidae	272	Mugilidae	132
Ephippidae	257	Triglidae	127
		Trichiuridae	86
		Tetraodontidae	85
		Gerridae	83
		Stromateidae	51
		Gadidae	50
		Ogcocephalidae	17
		Ephippidae	15

TABLE 63

The most numerous fishes taken in minnow seines on the bay flats and the Gulf beach and the numbers caught are given.

Bays		Gulf	
Family	Number	Family	Number
Menidia beryllina peninsulae	9,999	Harengula macropthalma	2,143
Cyprinodon variegatus variegatus	6,672	Anchoa mitchilli diaphana	1,354
Anchoa mitchilli diaphana	4,999	Anchoa hepsetus	1,117
Mugil cephalus	3,996	Polydactylus octonemus	900
Fundulus similis	1,359	Trachinotus carolinus	535
Brevoortia sp.	495	Mugil cephalus	526
Membras vagrans vagrans	483	Membras vagrans vagrans	227
Lucania parva venusta	476	Mugil curema	188
Fundulus grandis	454	Menidia beryllina peninsulae	248
Mugil curema	404		
Lagodon rhomboides	391		
Harengula macropthalma	332		
Micropogon undulatus	282		
Gobiosoma bosc	171		
Synathus scovelli	150		

TABLE 64

The most numerous fishes taken in trawls in the bays and the Gulf are given in the order of numbers caught.

Bays		Gulf	
Micropogon undulatus	14,277	Cynoscion nothus	1,748
Anchoa mitchilli diaphana	4,635	Micropogon undulatus	1,151
Galeichthys felis	2,265	Polydactylus octonemus	856
Cynoscion arenarius	2,148	Galeichthys felis	708
Bagre marina	831	Cynoscion arenarius	335
Leiostomus xanthurus	797	Vomer setapinnis	291
Brevoortia sp.	694	Stellifer lanceolatus	289
Polydactylus octonemus	530	Symphurus plaguisa	244
Dorosoma cepedianum	402	Leiostomus xanthurus	224
Lagodon rhomboides	373	Syacium gunteri	192
Signalosa mexicana	229	Menticirrhus americanus	181
Orthopristes chrysopterus	206		

TABLE 65

The most numerous fishes taken in trammel nets on the bay flats and in beach seines on the Gulf beach are given in order of the numbers caught.

Bays		Gulf	
Mugil cephalus	372	Leiostomus xanthurus	51
Cynoscion nebulosus	321	Mugil cephalus	36
Sciaenops ocellata	314	Dasyatis sabina	22
Dorosoma cepedianum	289	Polydactylus octonemus	22
Galeichthys felis	247	Chloroscombrus chrysurus	22
Pogonias cromis	156	Trachinotus carolinus	21
Micropogon undulatus	121	Galeichthys felis	18
Lagodon rhomboides	119	Pogonias cromis	15
Brevoortia sp.	95		
Leiostomus xanthurus	92		

TABLE 66

Lists are given of the fishes that spawned when the water temperature was rising or high and those that spawned when it was falling or low. The time of appeareance of the young, as given in the text, was used as an indication of the time of spawning in cases where ripening gonads were not noted.

Fishes that breed at the time of rising or high temperatures.	
Isogomphodon limbatus	Caranx hippos
Harengula macropthalma	Chloroscombrus chrysurus
Brevoortia sp.	Trichinotus carolinus
Brevoortia tyrannus	Pomatomus saltatrix
Anchoa hepsetus	Lobotes surinamensis
Anchoa mitchilli diaphana	Orthopristes chrysopterus
Bagre marina	Larimus fasciatus
Galeichthys felis	Bairdiella chrysura
Synodus foetens	Stellifer lanceolatus
Luciania parva venusta	Menticirrhus americanus
Fundulus grandis	Menticirrhus littoralis
Fundulus similis	Pogonias cromis
Cyprinodon variegatus variegatus	Cynoscion arenarius
Syngnathus scovelli	Cynoscion nebulosus
Menidia beryllina peninsulae	Cynoscion nothus
Membras vagrans vagrans	Prionotus tribulus
Mugil curema	Sphoeroides marmoratus
Polydactylus octonemus	Citharichthys spilopterus
Trichiurus lepturus	Achirus lineatus
Poronotus triacanthus	

Fishes that breed at the time of falling or low temperatures.	
Lepisosteus spathula	Leiostomus xanthurus
Adinia multifasciata	Micropogon undulatus
Mugil cephalus	Paralichthys lethostigma
Lagodon rhomboides	Symphurus plagiusa
Sciaenops ocellata	

TABLE 67

This table, divided into three parts, gives the average number of fishes caught per haul each season in each different type of net in Copano Bay, Aransas Bay and the Gulf of Mexico.

Minnow Seines

	Summer	Fall	Winter	Spring
Copano	284.0	138.0	280.5	113.6
Aransas	276.4	181.5	394.5	98.5
Gulf	220.0	268.2	57.6	158.2

Trawls

	Summer	Fall	Winter	Spring
Copano	418.6	295.1	142.3	497.0
Aransas	714.9	332.2	201.9	362.8
Gulf	326.7	310.0	322.0	350.6

Large Nets

	Summer	Fall	Winter	Spring
Copano	15.7	21.6	40.8	7.7
Aransas	35.0	19.5	12.8	7.1
Gulf	15.3	15.5	7.8	6.2

TABLE 68

This table gives the monthly average catch per haul of fishes taken in minnow seines in Copano and Aransas Bays and the Gulf of Mexico.

	1941							1942			
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Copano	92.5	641.0	158.0	74.2	111.5	228.7	222.2	522.0	147.2	83.5	114.0
Aransas	475.4	233.2	244.5	204.8	168.0	156.7	128.2	484.2	672.5	121.0	85.0
Gulf	249.5	152.0	248.5	121.0	582.0	398.0	4.0	53.5	111.5	162.4	149.0

	1942					
	May	June	Aug.	Sept.	Oct.	Nov.
Copano	143.2	97.0	368.2	____	____	____
Aransas	93.3	181.2	193.2	____	____	____
Gulf	____	165.0	319.0	420.5	61.0	26.5

TABLE 69

The monthly average catch per haul of fishes in trawl hauls are shown for Copano Bay, Aransas Bay and the Gulf of Mexico.

	1941									
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Copano	____	257.5	671.3	486.3	400.3	531.5	396.0	167.0	89.0	22.0
Aransas	40.5	262.0	____	1,607.7	371.3	521.5	495.5	286.2	214.7	126.7
Gulf	____	____	____	218.0	108.0	709.0	165.0	159.5	605.5	____

	1942					
	Jan.	Feb.	Mar.	Apr.	May	Aug.
Copano	145.3	259.7	385.7	591.0	519.7	231.5
Aransas	92.0	383.7	362.8	610.3	____	294.7
Gulf	322.0	____	382.0	396.5	257.5	____

TABLE 70

The monthly average catch per haul of fishes taken in trammel nets in the bays and large seines on the Gulf beach are shown.

	1941						
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Copano	17.7	10.7	15.0	7.3	6.8	30.8	36.8
Aransas	135.0	21.7	15.0	7.3	12.8	11.0	12.5
Gulf	.....	19.5	.....	.....	19.0	13.8	3.5

	1942							
	Jan.	Feb.	Mar.	Apr.	May	June	Aug.	Oct.
Copano	63.8	18.8	6.0	6.0	11.0	6.3	28.0	39.5
Aransas	13.5	12.5	9.2	4.0	7.0	20.0	19.8	44.0
Gulf	14.0	6.0	9.7	1.0	.....	20.5	6.0	.....

TABLE 71

The average temperatures and salinities, taken from all stations, are given for the two bays during December, 1941, and January, 1942. There were eight stations in Copano Bay and twelve in Aransas Bay. All January stations were visited after a freeze and temperatures had risen sharply from what they were at the time of the freeze.

	Copano		Aransas	
	December, 1941	January, 1942	December, 1941	January, 1942
Air T. ° C.	18.8	17.1	16.6	14.8
Water T. ° C.	17.5	15.3	16.3	12.2
Salinity parts per thousand	11.3	12.0	19.3	17.1

TABLE 72

The species and number of fishes taken in Aransas and Copano Bays at all stations are given for December, 1941, and January, 1942. All January stations were visited after the freeze. Two species of shrimp are included.

	Aransas Bay			Copano Bay		
	Dec., 1941	Jan., 1942		Dec., 1941	Jan., 1942	
		Alive	Dead		Alive	Dead
Dasyatis sabina	9	———	———	———	———	———
Anchoa hepsetus	———	1	———	95	392	38
Anchoa mitchilli diaphana	98	276	4	———	———	———
Brevoortia sp.	62	12	———	1	3	———
Dorosoma cepedianum	———	———	———	33	184	———
Signalosa mexicana	1	12	———	———	2	———
Galeichthys felis	49	———	6	2	———	———
Synodus foetens	8	———	———	———	———	———
Fundulus grandis	2	7	———	10	55	———
Fundulus similis	109	11	———	7	70	———
Cyprinodon variegatus variegatus	356	175	———	613	1,627	———
Lucania parva venusta	6	11	———	99	175	———
Adinia multifasciata	4	1	———	4	———	———
Syngnathus louisianae	1	———	———	———	———	———
Syngnathus sp.	20	———	———	38	7	———
Menidia beryllina peninsulae	244	340	1	24	128	10
Mugil cephalus	24	2,356	———	46	33	———
Trichiurus lepturus	10	———	———	———	———	———
Vomer setapinnis	1	———	———	———	———	———
Poronotus triacanthus	3	1	———	———	———	———
Lutianus griseus	———	———	1	———	———	———
Orthopristes chrysopterus	13	———	———	———	———	———
Lagodon rhomboides	1	11	———	———	1	———
Archosargus probatocephalus	———	———	———	———	1	———
Eucinostomus sp.	14	———	———	2	———	———
Bairdiella chrysura	3	———	———	1	———	———
Stellifer laceolatus	42	———	2	2	———	———
Sciaenops ocellata	11	7	———	41	13	———
Leiostomus xanthurus	4	5	———	1	———	———
Micropogon undulatus	38	38	———	13	44	———
Menticirrhus americanus	19	———	1	———	———	———
Menticirrhus littoralis	———	———	1	———	———	———
Pogonias cromis	3	3	———	31	21	———
Cynoscion arenarius	39	———	———	3	———	8
Cynoscion nothus	50	———	———	———	———	———
Cynoscion nebulosus	8	25	———	16	13	———
Unidentified gobies	6	———	———	———	———	———
Gobionellus hastatus	———	———	12	———	———	———
Gobiosoma bosc	2	3	———	19	7	———
Prionotus sp.	1	———	———	———	———	———
Chilomycterus schoepfi	2	———	———	———	———	———
Sphoeroides marmoratus	9	2	———	2	———	1
Paralichthys lethostigma	3	1	———	1	1	———
Citharichthys spilopterus	5	———	———	———	———	1
Etropus crossotus	30	———	———	———	———	———
Symphurus plagiusa	4	1	———	———	———	———
Achirus fasciatus	1	———	———	6	———	———
Achirus lineatus	1	———	———	1	1	———
Penaeus setiferus (Commercial shrimp)	4900–5600 (estimate)	2	33	500–600 (estimate)	———	———
Penaeus aztecus (?)	71	1	———	20	———	———

TABLE 73

This table gives the numbers of living and dead animals, of the three species with dead specimens common to both bays, taken after the freeze of January, 1942. It is derived from Table 83. Mortality was heavier in Copano Bay, the inside and shallower bay.

	Aransas Bay		Copano Bay	
	Alive	Dead	Alive	Dead
Anchoa mitchilli diaphana	276	4	392	38
Menidia beryllina peninsulae	340	1	128	10
Penaeus setiferus	2	33	0	55
Totals	618	38	520	103

TABLE 74

The most numerous fishes are classified according to the salinities where they were caught.

Fishes taken only at very low salinities.

Lepisosteus productus
Ictiobus bubalus
Ictalurus furcatus
Ameiurus melas catalus

Fishes most abundant at low salinities (below 15.0 per mille) and uncommon or absent at high salinities

Lepisosteus spathula
Dorosoma ceperianum
Lucania parva venusta
Archosargus probatocephalus

Fishes most abundant at low salinities (below 15.0 per mille) but which were also present in numbers at high salinities.

Fundulus grandis
Sciaenops ocellata
Pogonias cromis
Cynoscion nebulosus
Paralichthys lethostigma

Fishes most abundant at medium salinities (10.–25.0 per mille) but which were present at low or high salinities. or both.

Brevoortia sp.
Signalosa mexicana
Bagre marina
Adinia multifasciata
Cyprinodon variegatus variegatus
Mugil cephalus.

Fishes most abundant at high salinities (above 25.0 per mille) but which were taken at lower salinities.

Dasyatis sabina
Harengula macropthalma
Anchoa hepsetus
Galeichthys felis
Synodus foetens
Urophycis floridanus
Polydactylus octonemus
Poronotus triacanthus
Caranx hippos
Chloroscombrus chrysurus
Orthopristes chrysopterus
Stellifer lanceolatus
Menticirrhus americanus
Menticirrhus littoralis
Cynoscion nothus
Chaetodipterus faber
Prionotus tribulus
Chilomycterus schoepfi
Achirus fasciatus
Symphurus plagiusa

Fishes taken in large numbers at all salinities.

Anchoa mitchilli diaphana
Fundulus similis
Menidia beryllina peninsulae
Membras vagrans vagrans
Lagodon rhomboides
Bairdilella chrysura
Leiostomus xanthurus
Micropogon undulatus
Cynoscion arenarius

TABLE 75

The species of fishes not taken below a given salinity are given under that salinity in the table. They may have been taken at any higher salinity, but at none below it.

Fishes not taken below a salinity of 30.0.

Hypoprion brevirostris
Raja texana
Narcine brasiliensis
Pteroplatea micrura
Anchoa lyolepis
Sphyraena quachancho
Scomberomorus maculatus
Peprilus paru
Trachurus lathami
Selene vomer
Trachinotus palometa
Centropristes philadelphicus
Conodon nobilis
Gerres rhombeus
Upeneus martinicus
Scorpaena ginsburgi
Prionotus pectoralis
Lepophidium brevibarbe
Rissola marginata
Otophidium welshi
Balistes capriscus
Lactophrys tricornis
Ogcocephalus vespertilio
Syacium gunteri
Citharichthys macrops

Fishes not taken below a salinity of 25.0.

Dasyatis americana
Pomolobus chrysochlorus
Optisthonema oglinum
Brevoortia tryannus
Hippocampus regulus
Trachinotus carolinus
Larimus fasciatus
Prionotus beanii
Prionatus punctatus
Prionotus scitelus
Ogcocephalus nasutus

Fishes not taken below a salinity of 20.0.

Spyhrna tiburo
Lobotes surinamensis
Chilomycterus schoepfi
Ancylopsetta quadrocellata

Fishes not taken below a salinity of 15.0.

Syngnathus louisianae
Poronotus triacanthus
Hemicaranx rhomboides
Vomer setapinnis
Chloroscombrus chrysurus
Pomatomus saltatrix
Menticirrhus littoralis
Cynoscion nothus
Prionotus tribulus
Astroscopus y-graecum
Opsanus sp.
Symphurus plagiusa

Fishes not taken below a salinity of 10.0.

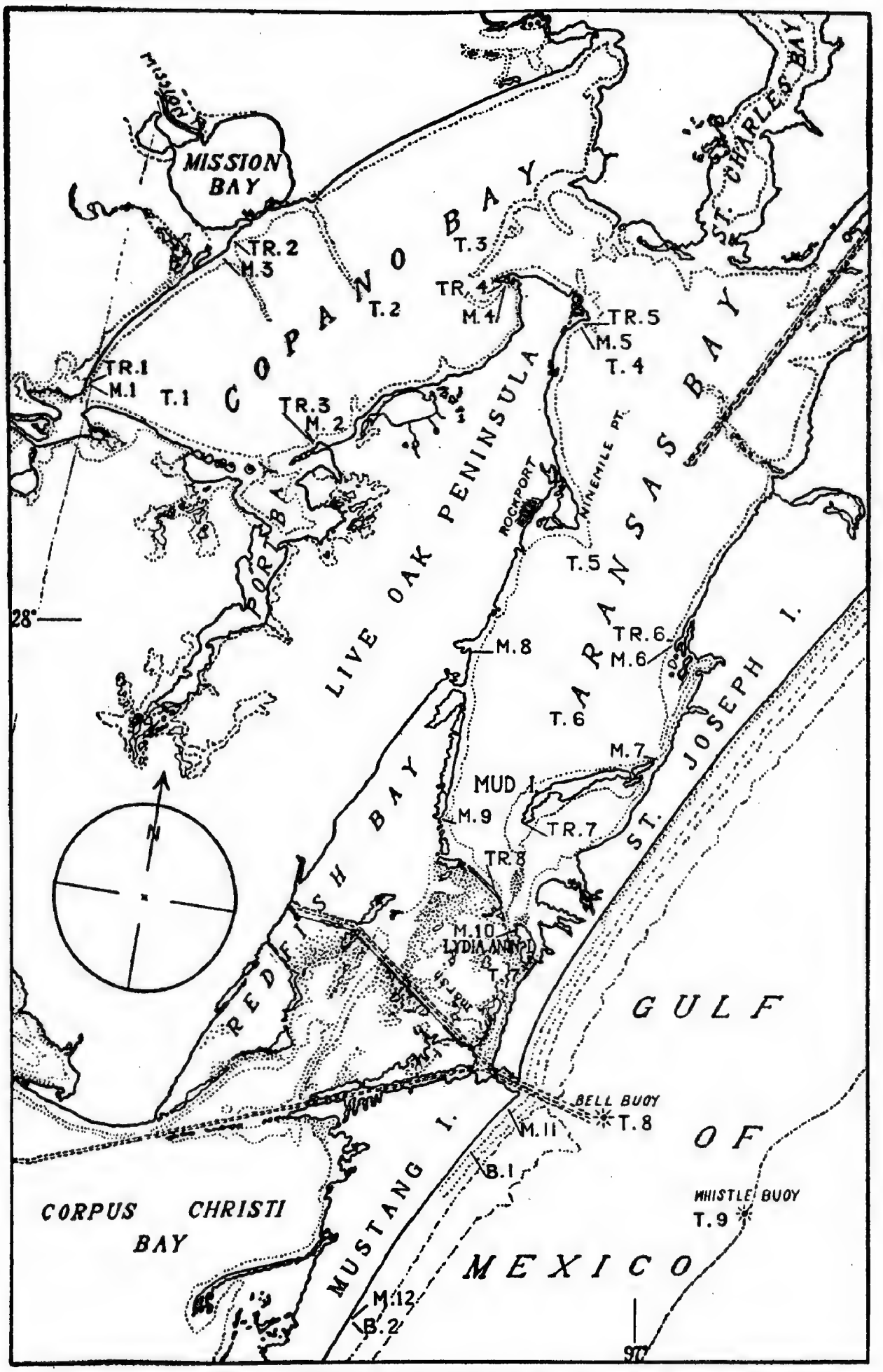
Isogomphodon limbatus
Synodus foetens
Mollienisia latipinna
Hyporhamups unifasciatus
Syngnathus mackayi
Urophycis floridanus
Trichiurus lepturus
Orthopristes chrysopterus
Menticirrhus americanus
Chaetodipterus faber
Gobionellus boleosoma
Everthodes lyricus
Opsanus beta
Nautopaedium porossisimum
Gobiesox strumosus

Fishes not taken below a salinity of 5.0.

Adinia multifasciata
Oligoplites saurus
Eucinostomus spp.
Stellifer lanceolatus
Gobionellus hastatus
Paralichthys albigutta

Fishes taken below a salinity of 5.0.

Lepisosteus spathula
Elops saurus
Tarpon atlanticus
Harengula macropthalma
Brevoortia sp.
Dorosoma cepidianum
Signalosa mexicana
Anchoa hepsetus
Anchoa mitchilli diaphana
Bagre marina
Galeichthys felis
Lucania parva venusta
Fundulus grandis
Fundulus similis
Cyprinodon variegatus variegatus
Strongylura marina
Syngnathus scovelli
Menidia beryllina peninsulae
Membras vagrans vagrans
Mugil cephalus
Mugil curema
Polydactylus octonemus
Caranx hippos
Lagodon rhomboides
Archosargus probatocephalus
Bairdiella chrysura
Sciaenops ocellata
Leiostomus xanthurus
Micropogon undulatus
Pogonias cromis
Cynoscion arenarius
Cynoscion nebulosus
Gobiosoma bosc
Sphoeroides marmoratus
Citharichthys spilopterus
Etropus crossotus
Paralichthys lethostigma
Achirus fasciatus
Achirus lineatus



SCALE: ONE AND ONE-EIGHTH INCHES EQUALS APPROXIMATELY FIVE MILES

Figure 1. The map shows the area where the work was done. Trammel net stations are marked Tr. 1, Tr. 2, etc. The beach seine stations are marked B. 1 and B. 2. The Minnow seine stations are marked M. 1, M. 2, etc. Trawl stations are marked T. 1, T. 2, etc.

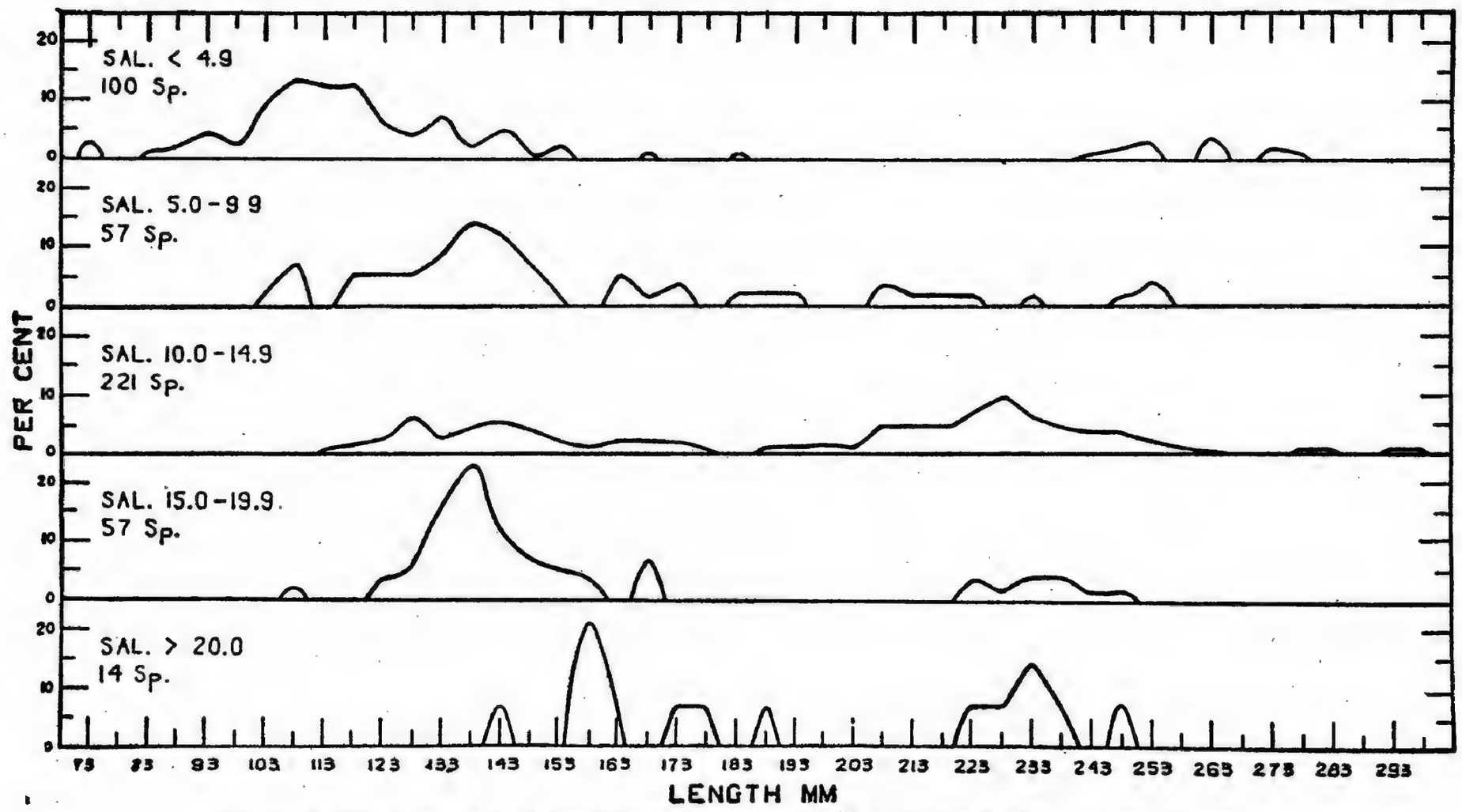


Figure 2. This gives the total length-frequency curves of all specimens of *Dorosoma cepedianum*, the gizzard shad, taken at different ranges of salinity. The salinity ranges and the number of specimens measured are given on the left of the figure.

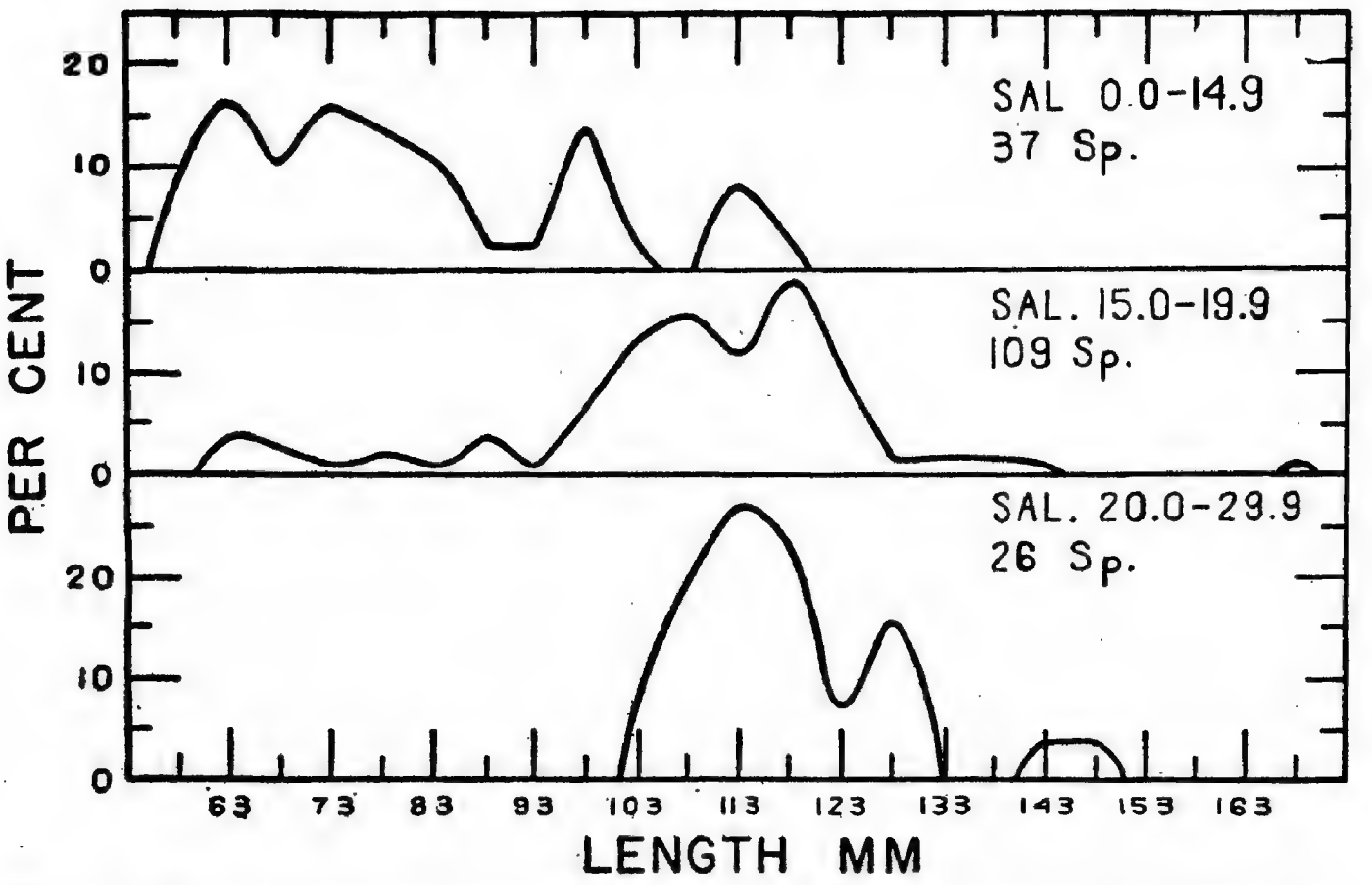


Figure 3. The length-frequency curves of all specimens of *Signalosa mexicana*, the Mexican gizzard shad, taken at the given salinity ranges are shown. The number of specimens are given.

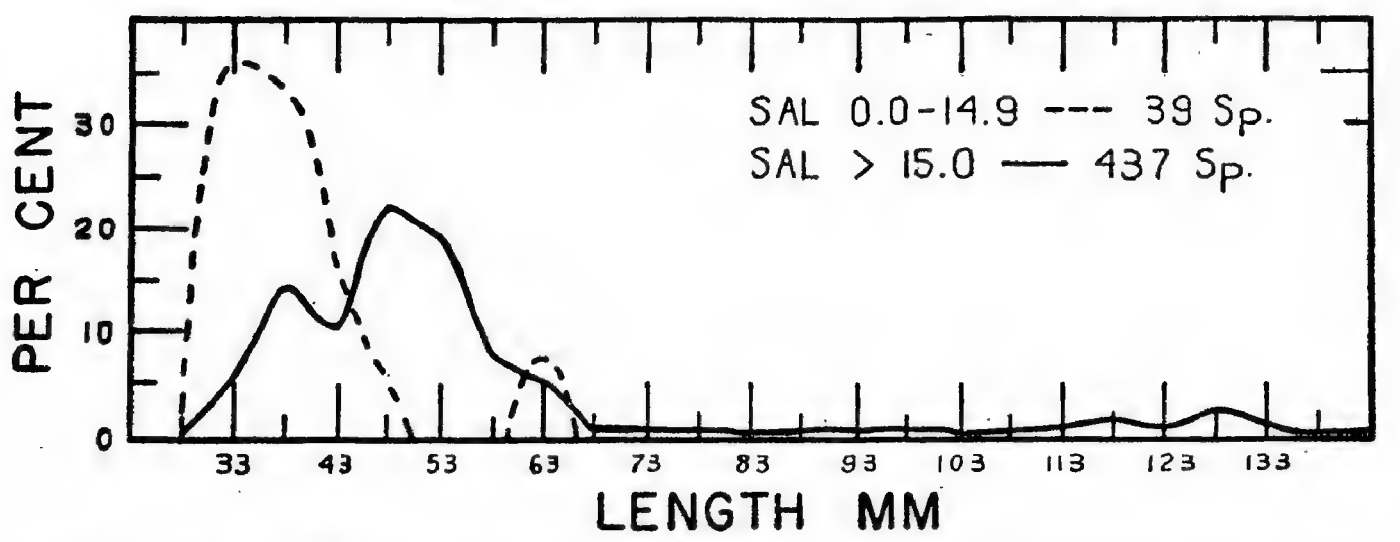


Figure 4. The total length-frequency of all specimens of the anchovy, *Anchoa hepsetus*, taken at salinities below 14.9 per mille and above 15.0 per mille are given. The number of specimens that were measured are given.

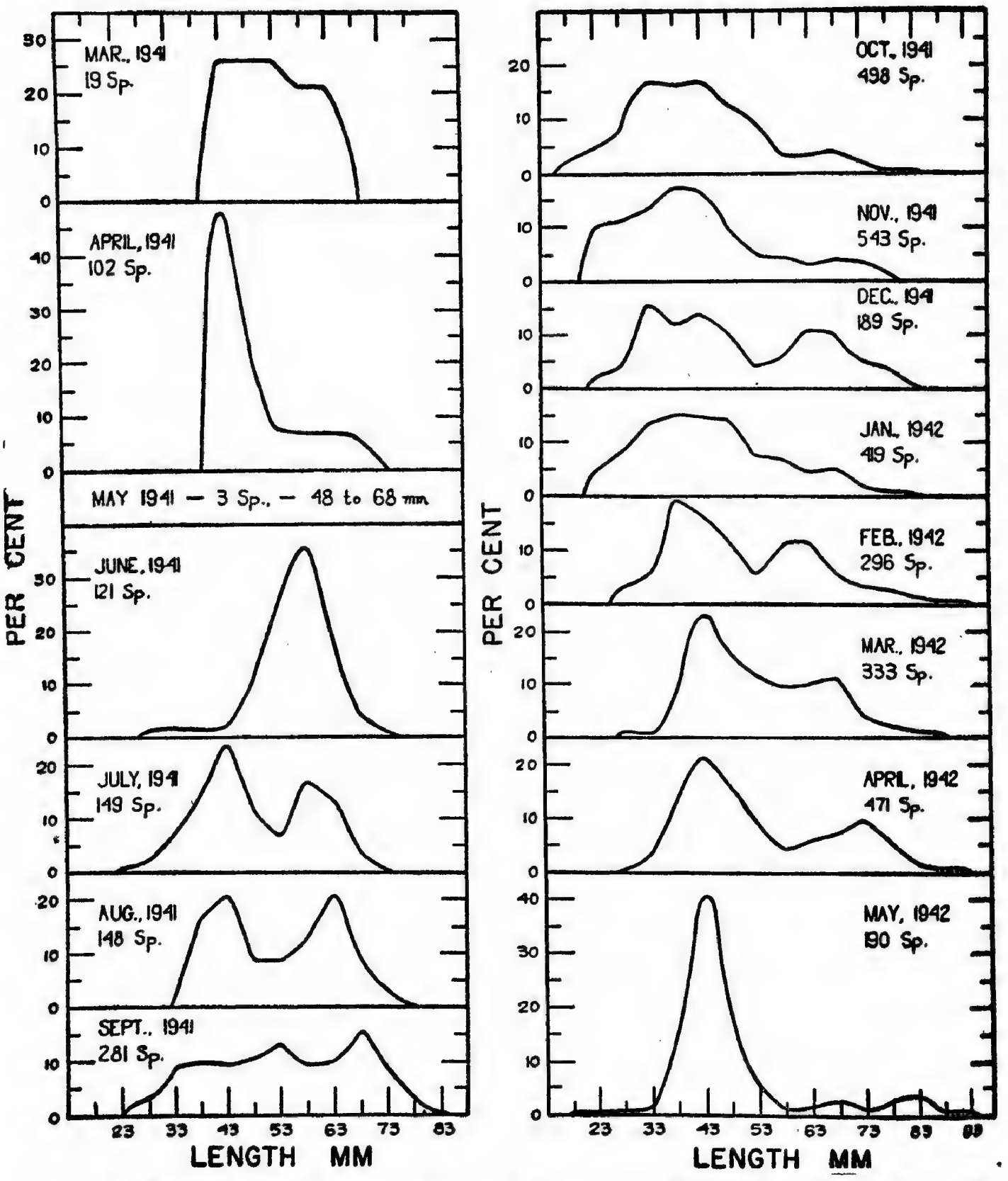


Figure 5. The total length-frequency curves of the anchovy, *Anchoa mitchilli diaphana*, are shown for the given months. The combined data for all localities is presented. The number of specimens measured are given. In May, 1941, only 3 fish were caught and the total length range is given.

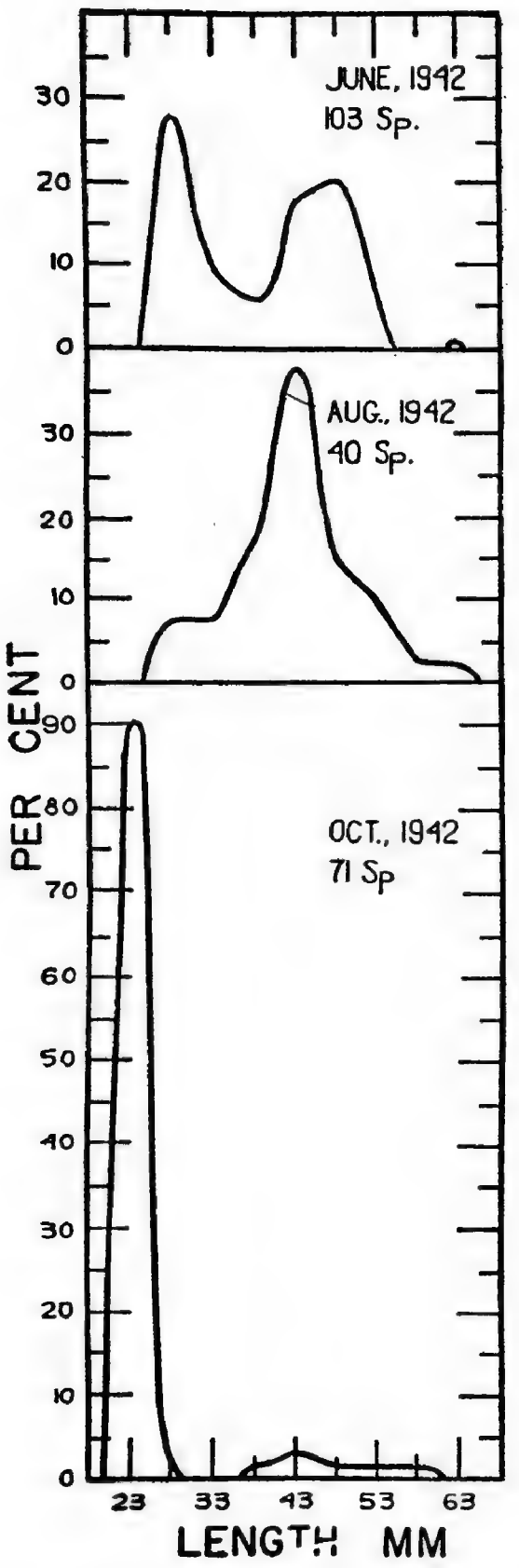


Figure 5—Continued. See the previous figure for the explanation.

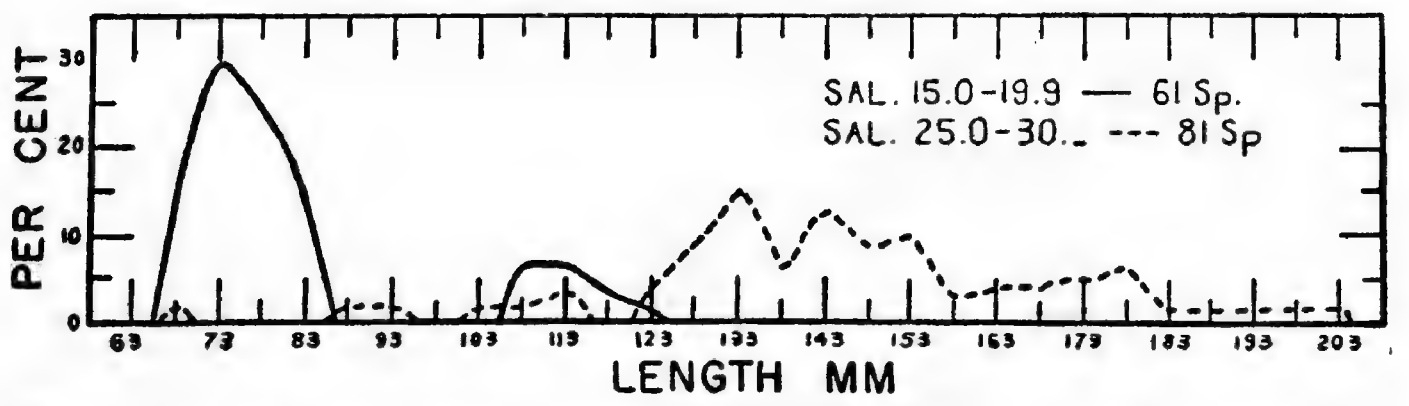


Figure 6. The total length-frequency curves of the silverside, *Menidia beryllina peninsulae*, taken at the given salinity ranges are shown. The number of specimens measured are given.

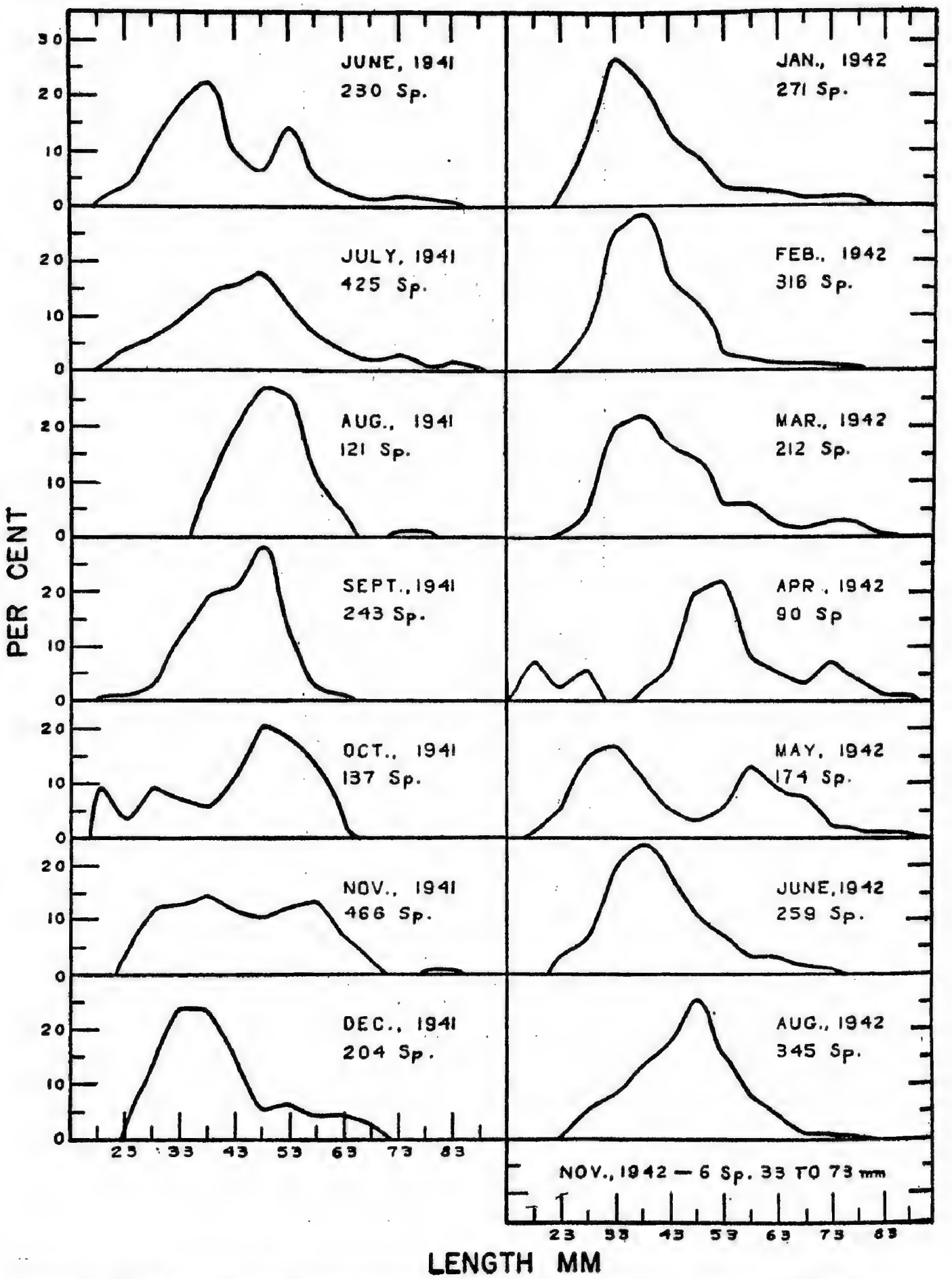


Figure 7. The monthly total length-frequency curves of the silverside, *Menidia beryllina peninsulae*, are shown. Fish taken at all localities were used. The number of specimens measured monthly are given.

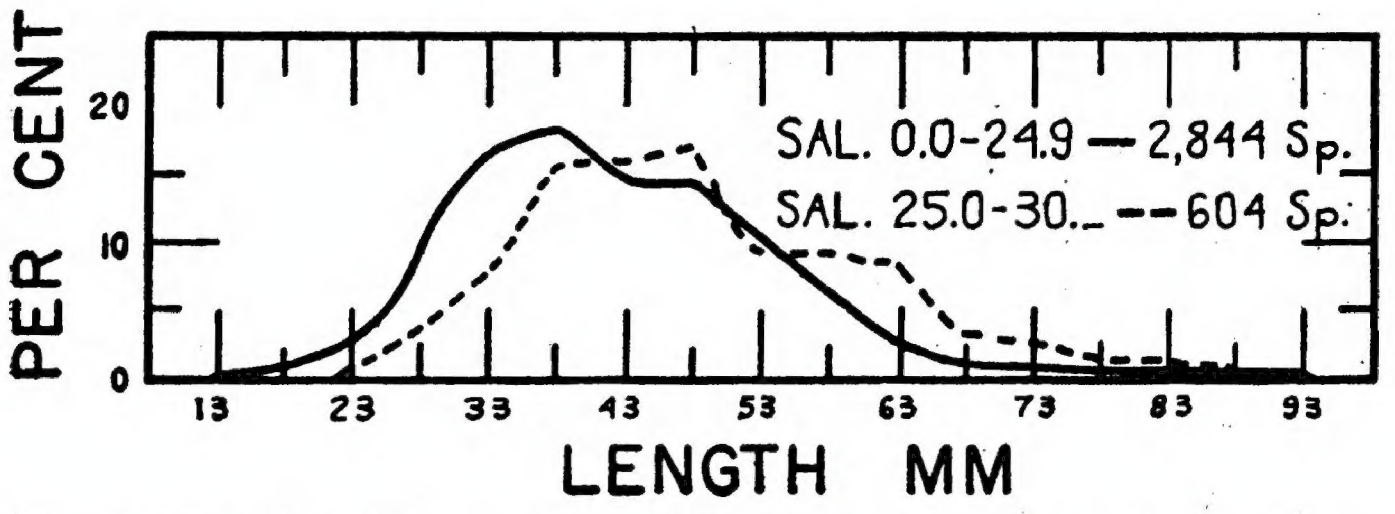


Figure 8. The total length-frequency curves of *Chloroscombrus chrysurus*, the bumper, taken at the given salinity ranges are shown. The number of specimens measured are given.

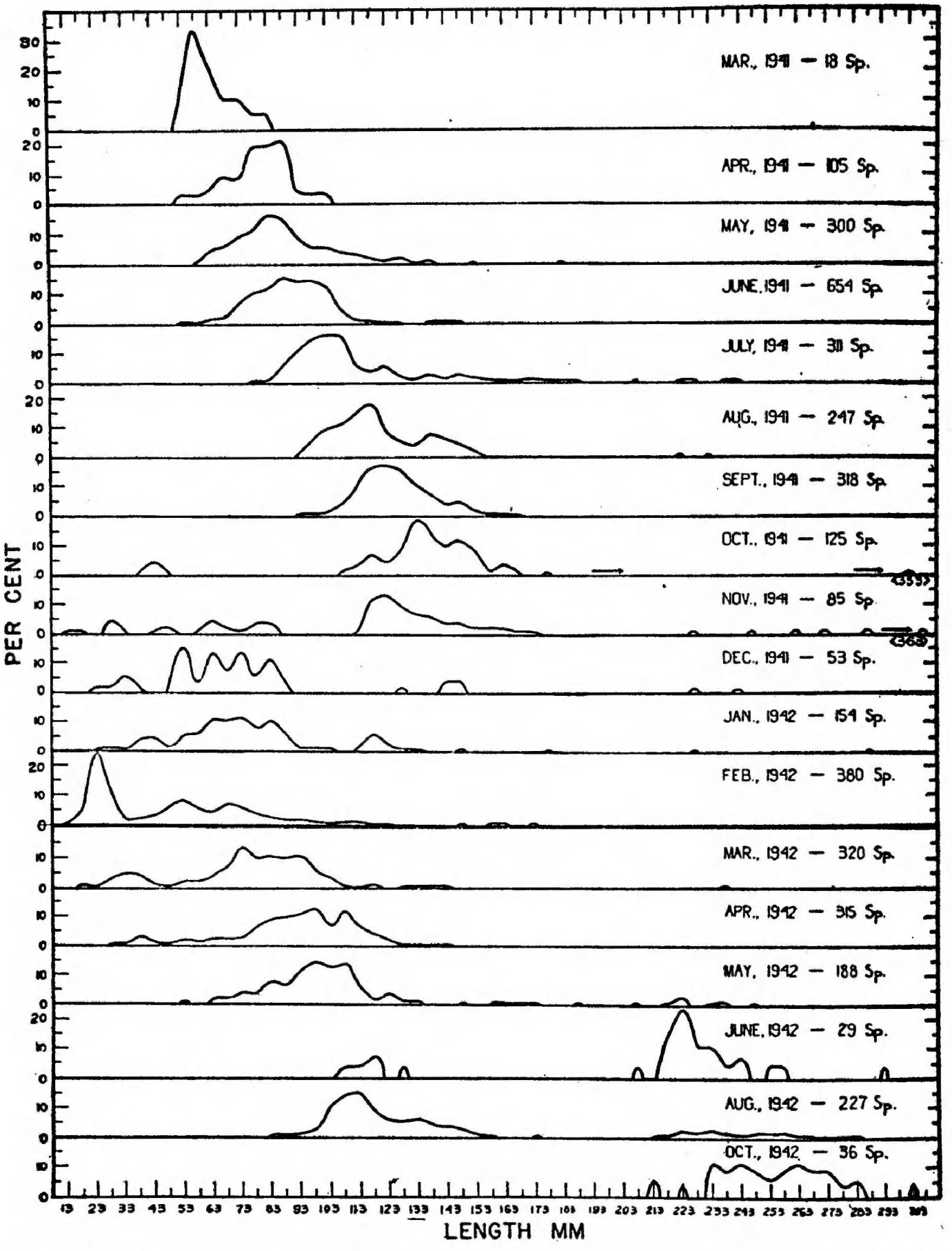


Figure 9. The monthly total length-frequency curves of the croaker, *Micropogon undulatus*, taken at all localities are shown. The number of fish measured each month are given.

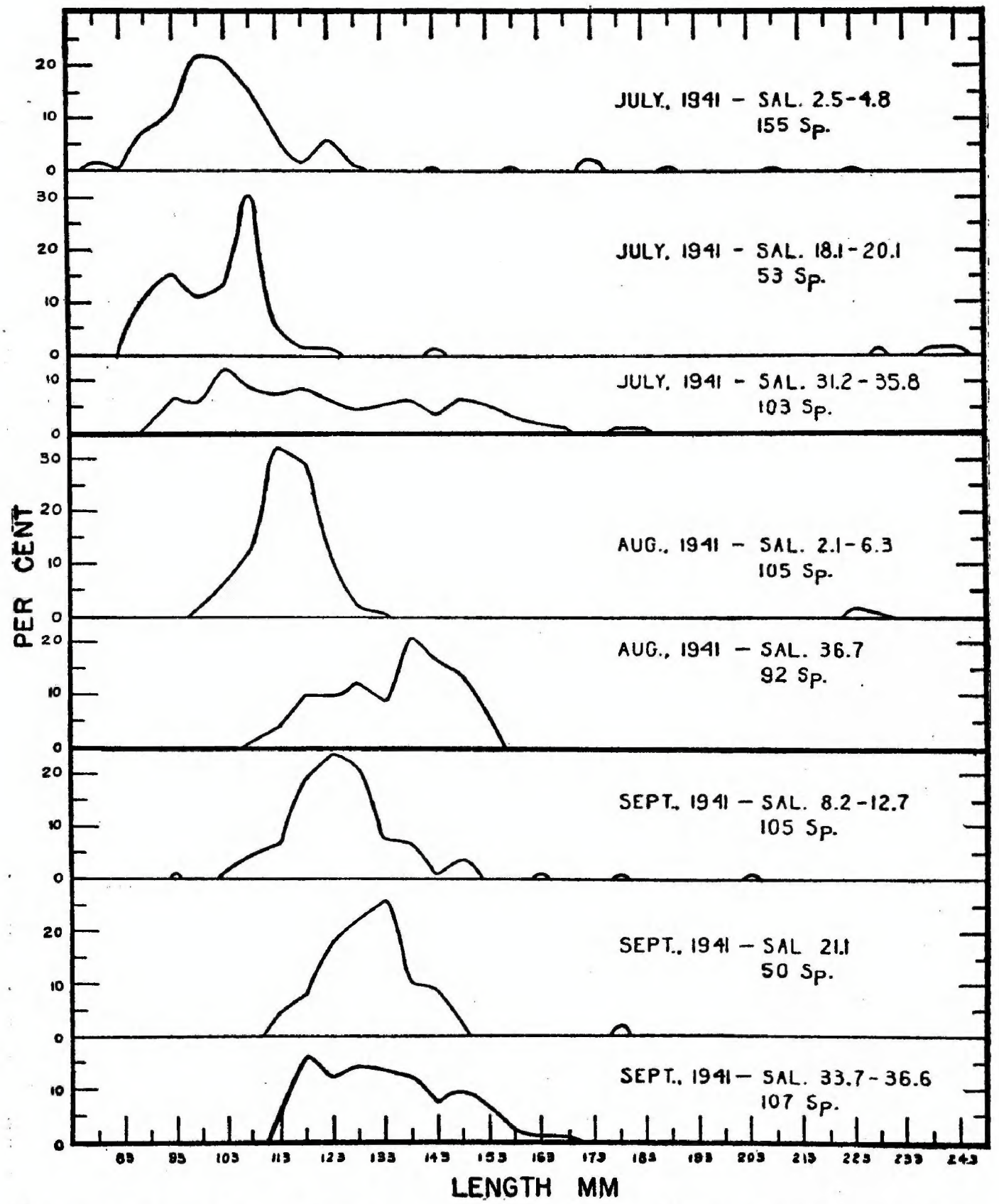


Figure 10. The total length-frequency curves of all croakers, *Micropogon undulatus*, taken at the stated salinity ranges, not more than eight days apart during the months shown, are presented. The number of fish measured are given.

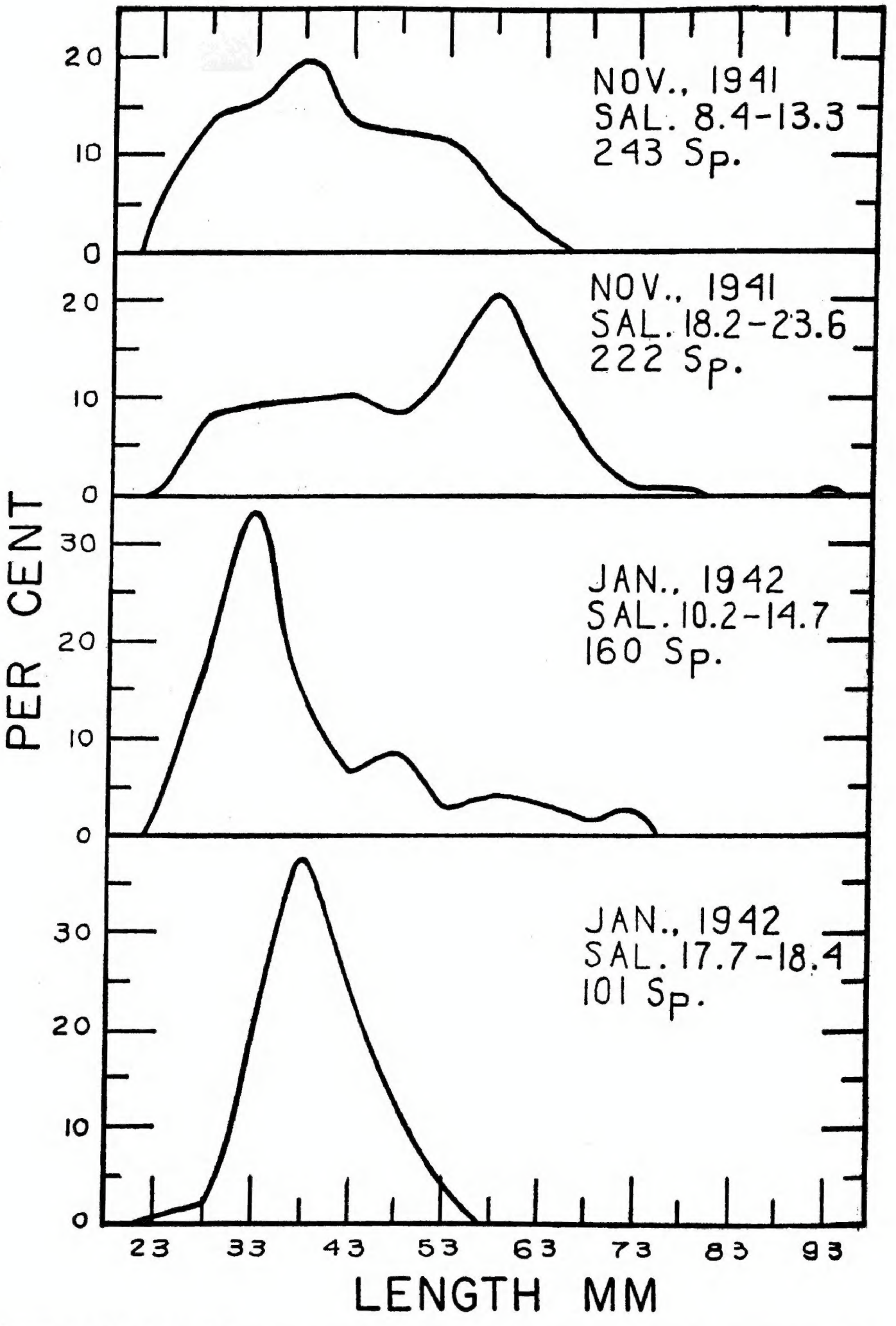


Figure 11. Total length-frequency curves of the silverside, *Menidia beryllina peninsulae*, taken at the salinity ranges given, not more than eight days apart in the given months, are shown The number of fish measured are given.